MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
SBIR 08.3 Supplemental Proposal Submission Instructions

INTRODUCTION

The MDA SBIR/STTR Program is implemented, administrated and managed by the MDA Office of Small Business Programs (OSBP). If you have any questions regarding the administration of the MDA SBIR/STTR Program please call 703-553-3418 or e-mail: sbirsttr@mda.mil. Additional information on the MDA SBIR/STTR Program can be found on the MDA SBIR/STTR home page at http://www.mdasbir.com/. Information regarding the MDA mission and programs can be found at http://www.mda.mil.

Questions About SBIR and Solicitation Topics

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8:00 am to 5:00 pm EST). For technical questions about the topic during the pre-solicitation period (28 July 2008 through 24 Aug 2008), contact the Topic Authors listed under each topic on the http://www.dodsbir.net Web site by 24 Aug 2008. Please Note: During the pre-release period, you may talk directly with the Topic Authors to ask technical questions about the topics. Their names, phone numbers, and e-mail addresses are listed within each solicitation topic. For reasons of competitive fairness, direct communication between proposers and topic authors is not allowed when DoD begins accepting proposals for each solicitation. However, proposers may still submit written questions about solicitation topics through the SBIR/STTR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing until the solicitation closes. All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other significant information, relevant to the SBIR/STTR topic under which they are proposing.

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors:
Only Government personnel will evaluate proposals. In some circumstances, non-government, technical personnel from the following Federally Funded Research and Development Centers (FFRDCs) and support contractors will provide advisory and assistance services to MDA, including providing technical analyses of proposals submitted against MDA topics and of applications submitted to the MDA Phase II Transition Program.

FFRDCs: Massachusetts Institute of Technology Lincoln Laboratory

Universities / Non-Profit Organizations: Aerospace Corporation, Draper Laboratory, Institute of Defense Analyses, Johns Hopkins University Applied Physics Laboratory (JHU/APL,), MITRE Corporation, University of New Mexico, Utah State University Space Dynamics Laboratory.

Support Contractor Organizations: Aerothermo Technologies, Inc., BFA Systems, Booz Allen Hamilton, Coleman Technologies, Inc, CACI International, Inc., Computer Science, Inc., Computer Sciences Corporation (CSC), deciBel Research, Inc., DESE Research, Inc., Dynamic Research Corporation, Inc., Engineering Research and Consulting (ERC), Lockheed Martin, ManTech/SRS Technologies, Millennium Engineering and Integration, Inc., Modern Technology Solutions, Inc., Northrop Grumman, Paradigm Technologies, People Tech, Radiance Technology, Schafer Inc., Science

Applications International Corporation (SAIC), Science and Technology Associates, Inc. (STA), Sparta, Inc., SYColeman Corporation.

Individual support contractors from these organizations will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These organizations are expressly prohibited from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

Pursuant to FAR 9.505-4, the MDA contracts with these support contractors include a clause which essentially requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR Program Management Office (PMO).

Conflicts of Interest

You must avoid any actual or potential organizational conflicts of interest (OCI) while participating in any MDA-funded contracts, regardless of whether it was awarded by MDA. You must report to the MDA SBIR/STTR Program Office via e-mail any potential OCI before submitting your proposal or application. The MDA SBIR/STTR Program Office will review and coordinate any possible solutions or mitigation to the potential conflict with the contracting officer. If you do not make a timely and full disclosure and obtain clearance from the contracting officer, MDA may reject your proposal or application, or terminate any awarded contracts for default. See FAR Subpart 9.5 for more information on organizational conflicts of interest.

PHASE I GUIDELINES

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept, with a cost not exceeding $100,000. Only UNCLASSIFIED proposals will be entertained.

A list of the topics currently eligible for proposal submission is included in section 8, below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

<u>Please assure that your mailing address, e-mail address, and point of contact (Corporate Official) listed in the proposal are current and accurate. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.</u>

PHASE I PROPOSAL SUBMISSION

Read the DoD front section of this solicitation, including Section 3.5, for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this Solicitation will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. MDA is not responsible for any money expended by the proposer before award of any contract.

If the offeror proposes to use foreign nationals: Identify the foreign nationals you expect to be involved on this project, country of origin and level of involvement. Please be prepared to provide the following information should your proposal be selected for award: individual's full name (including alias or other spellings of name); date of birth; place of birth; nationality; registration number or visa information; port of entry; type of position and brief description of work to be performed; address where work will be performed; and copy of visa card or permanent resident card.

The technology within some of the MDA topics is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. You must ensure that your firm complies with all applicable ITAR provisions. Please refer to the following URL for additional information: http://www.pmddtc.state.gov/itar_index.htm

You must submit the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report electronically through the DoD SBIR/STTR Web site at www.dodsbir.net/submission/SignIn.asp. If you have any questions or problems with the electronic proposal submission, contact the DoD SBIR/STTR Helpdesk at 1-866-724-7457. Refer to section 3.0 of the DoD solicitation for complete instructions and requirements.

MAXIMUM PAGE LIMIT FOR MDA IS **20 PAGES**

Only proposals submitted via the Submission Web site on or before the deadline of 6 a.m (EST) on 24 September 2008 will be processed. ***Please Note:*** The maximum page limit for your technical proposal is twenty (20) pages. Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. The following have been submitted electronically through the DoD submission site by 6 a.m. (EST) 24 September 2008.

_____ a. DoD Proposal Cover Sheet

_____ b. Technical Proposal (**DOES NOT EXCEED 20 PAGE**S): *Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.*

_____ c. DoD Company Commercialization Report (required even if your firm has no prior SBIRs).

_____ d. Cost Proposal **(Online cost proposal form is REQUIRED by MDA)**

____2. The Phase I proposed cost does not exceed $100,000.

MDA PROPOSAL EVALUATIONS

MDA will utilize the Phase I Evaluation criteria in Section 4.2 of the DoD solicitation, including potential benefit to the Ballistic Missile Defense System (BMDS) in assessing and selecting for award those proposals offering the best value to the Government.

MDA will use the Phase II Evaluation criteria in Section 4.3 of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS, in assessing and selecting for award those proposals offering the best value to the Government. In the Phase II Evaluations, Criterion C is more important than criteria A and B, individually. Criteria A and B are of equal importance.

In Phase I and Phase II, firms with a CAI at the 20th percentile will be penalized in accordance with DoD Section 3.5d.

Please note that potential benefit to the BMDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price. Where technical evaluations are essentially equal in merit, cost or price to the government will be considered in determining the successful offeror.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions only on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal and will count toward the applicable page limit.

INFORMATION ON PROPOSAL STATUS

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by e-mail regarding proposal selection or non - selection. If your proposal is tentatively selected to receive an MDA award, the PI and CO will receive a single notification. If your proposal is not selected for an MDA award, the PI and CO may receive up to two messages. The first message will provide notification that your proposal has not been selected for an MDA award and provide information regarding the ability to request a proposal debriefing. The second message will contain debrief status information (if requested), or information regarding the debrief request. **Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced.**

IMPORTANT: We anticipate having all the proposals evaluated and our Phase I contract decisions in the December 2008 timeframe. All questions concerning the evaluation and selection process should be directed to the MDA SBIR/STTR Program Management Office (PMO).

MDA SUBMISSION OF FINAL REPORTS

All final reports will be submitted in accordance with the Contract Data Requirements List (CDRL) of the resulting Contract. Refer to Section 5.3 of the DoD Solicitation for additional requirements.

PHASE II GUIDELINES

This Solicitation solicits Phase I Proposals. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be invited to submit a Phase II proposal. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal. MDA does encourage, but does not require, partnership and outside investment as part of discussions with MDA Sponsors for potential Phase II invitation.

Invitations to submit a Phase II proposal will be made by the MDA SBIR/STTR PMO. Phase II proposals may be submitted for an amount normally not to exceed $750,000. MDA may consider making Phase II Invitations not to exceed a maximum of $2.5M. **You may only propose up to the total cost for which you are invited.**

The MDA SBIR/STTR PMO does not provide "debriefs" for firms who were not invited to submit a Phase II proposal.

PHASE II PROPOSAL SUBMISSION

Phase II Proposal Submission is by Invitation only: *A Phase II proposal can be submitted only by a Phase I awardee and only in response to an invitation by MDA.* Invitations are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR/STTR Web site http://www.mdasbir.com/ for further instructions.

Classified proposals are not accepted under the DoD SBIR/STTR Program. Follow Phase II proposal instructions described in Section 3.0 of the Program solicitation at www.dodsbir.net/solicitation and specific instructions provided in the Phase II Invitation. Each Phase II proposal must contain a Proposal Cover Sheet, technical proposal, cost proposal and a Company Commercialization Report submitted through the DoD Electronic Submission Web site at www.dodsbir.net/submission/SignIn.asp **by the deadline specified in the invitation.**

MDA FAST TRACK DATES AND REQUIREMENTS

Introduction: For more detailed information and guidance regarding the DoD Fast Track Program, please refer to Section 4.5 of the solicitation and the Web site links provide there. MDA's Phase II Fast Track Program is focused on transition of technology. The Fast Track Program provides matching SBIR funds to eligible firms that attract investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II awards under Fast Track will be for $1.0M maximum, unless specified by the MDA SBIR/STTR Program Manager.

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)

- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)

Submission: The complete Fast Track application along with completed transition questions (see note below), must be received by MDA within 120 days from the Phase I award date. Your complete Phase II Proposal must be received by MDA within 30 days of receiving approval (see section entitled "Application Assessments" herein for further information). Any Fast Track applications or proposals not meeting this deadline may be declined. All Fast Track applications and required information must have a complete electronic submission. The DoD submission site www.dodsbir.net/submission/SignIn.asp will lead you through the process for submitting your application and technical proposal electronically. Each of these documents is submitted separately through the Web site.

Firms who wish to submit a Fast Track Application to MDA MUST utilize the MDA Fast Track Application Template available at http://www.mdasbir.com (or by writing sbirsttr@mda.mil). Failure to follow these instructions may result in automatic rejection of your application.

Firms who have applied for Fast Track and not selected may still be eligible to compete for a regular Phase II in the MDA SBIR/STTR Program.

Current guidance and instructions may be found at http://www.mdasbir.com.

MDA SBIR PHASE II TRANSITION PROGRAM

Introduction: To encourage transition of SBIR projects into BMDS, the MDA's Phase II Transition Program provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition, a non-SBIR/non-STTR government program or Private sector investments. The Phase II Transition Program allows for an existing Phase II SBIR contract to be extended for up to one year per Phase II Transition application, to perform additional research and development. Phase II Transition matching funds will be provided on a one-for-one basis up to a maximum amount of $500,000 of SBIR funds in accordance with DoD Phase II Enhancement policy at Section 4.6 of the DoD Solicitation. Phase II Transition funding can only be applied to an active DoD Phase II SBIR contract.

The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program may be obligated on the Phase II contract as a modification prior to or concurrent with the modification adding MDA SBIR funds, OR may be obligated under a separate contract. Private sector funds must be from an "outside investor" which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

Background: MDA's technologies are often managed via a Technology Maturation and Transition Program (TMTP) composed of two linked components, technology maturation and technology transition commitment. The TMTP is designed to ensure that all technology development programs in MDA map to a BMDS improvement and, after a period of development and maturity, are transitionable to targeted BMDS end users. End user is defined as the Element, Component or Product Manager to which it is intended to transition the technology. Because of this, it is important that your Phase II be at or approaching a Technology Readiness Level of either 5 or 6 (defined below) at time of application for the MDA Phase II Transition Program.

Current guidance and instructions may be found at http://www.mdasbir.com.

MDA SBIR 08.3 Topic Index

INTERCEPTOR TECHNOLOGY

The Interceptor Research Area funds innovative technologies that have the potential to increase the capabilities and effectiveness of future or present interceptors for the Ballistic Missile Defense System (BMDS).

MDA08-001	Cabling Architecture and Mechanisms
MDA08-002	Interceptor Seekers
MDA08-003	Advanced Synergistic Structures for Interceptor Kill Vehicles
MDA08-004	Interceptor Guidance, Navigation, and Control (GNC) Algorithms
MDA08-005	Advanced Divert and Attitude Control Systems (DACS)
MDA08-006	Interceptor Avionics
MDA08-007	Innovative Axial Propulsion Technology for Missile Defense Interceptors
MDA08-008	Target Instrumentation Technology
MDA08-009	Test Methodology and Equipment for Radiation Hardened Interceptors

SPACE TECHNOLOGY

The Space Technology Research area focuses on developing and transitioning technologies to enable or improve the operation of Ballistic Missile Defense System (BMDS) elements in the long-term orbital environment. Current emphasis is on technologies benefiting the Space Tracking and Surveillance System (STSS), but technologies enabling other elements are of longer term interest as well. One of the over-arching requirements for all work in this area is the ability to survive and operate in orbit: this means a tougher natural radiation environment (and potential enhancement by man-made threats) than on earth, the absence of atmosphere, and micro-gravity. Most of the efforts are hardware oriented, but software improvements are also of interest. These technologies will be ITAR restricted.

MDA08-010	Improved Cryogenic Cooling Technology
MDA08-011	Space Component Miniaturization
MDA08-012	Advanced Space Power Management & Energy Storage Technologies
MDA08-013	Advanced Space Sensor Components and Concepts
MDA08-014	Radiation-Hardened Memory
MDA08-015	Real Time Monitoring of Natural and Enhanced Space Environments
MDA08-016	Spacecraft Assembly, Integration and Test Enhancement
MDA08-017	Silicon Carbide (SiC) Cryogenic Optics Technology Advancement

MANUFACTURING AND PRODUCIBILITY

The Manufacturing and Producibility Research Area focuses on innovative technologies for manufacturing, assembly, and production at all levels of the Ballistic Missile Defense System (BMDS) Supply Chain.

MDA08-018	Manufacturing Process Maturation for Propulsion Technology
MDA08-019	Improved Performance, More Producible Long Wave IR Integrated Dewar Assemblies
MDA08-020	Advanced Missile Materials and Process Technologies
MDA08-021	A Risk Reduction Process for Enhanced Mission Assurance
MDA08-022	Ballistic Missile Defense System Innovative Power
MDA08-023	Radiation Hardened Producible Manufacturing
MDA08-024	Advanced Nitride Heterostructures for X-Band GaN HEMTs

RADAR SYSTEMS

The Radar Research Area focuses on innovative and/or enhanced technology development or "game changing" technology that improves radar functionality, packaging and/or affordability.

MDA08-025	High-Power RF-MEMS Phase Shifters for Phased-Array Applications
MDA08-026	Multistatic Sea-Based Radar Concepts and Architectures
MDA08-027	Wideband Beamformer
MDA08-028	Wideband Sub-Array Digital Receiver Exciter (DREX) Development and Packaging
MDA08-029	Wide Bandgap Semiconductor Power Inverters and Converters for Next Generation Transmit Receive (T/R) Module Power Supplies
MDA08-030	Calibration techniques for very large arrays
MDA08-031	Innovative Hardware Technologies for Anti-Jam and Electromagnetic Attack Rejection in Ballistic Missile Defense System (BMDS) Radars

MODELING, SIMULATION AND PHENOMENOLOGY

The Modeling, Simulation and Phenomenology Research Area funds technological innovations in Modeling & Simulation (M&S) to support development and testing of the Ballistic Missile Defense System (BMDS). Ballistic Missile Defense System-Level Simulation Optimization

MDA08-032	Integrated UV/VIS/IR background phenomenology models for radiation transport system trades
MDA08-033	Exploitation of Alternative Wavelengths for Propulsion Related Signature Events
MDA08-034	Enhancements to Continuum Plume Flowfield Models for Transitional Flow Simulations
MDA08-035	Signature Prediction and Uncertainty Analysis for Radar-based MDA Applications
MDA08-036	Ballistic Missile Defense System-Level Simulation Optimization

COMMAND, CONTROL, BATTLE MANAGEMENT AND COMMUNICATIONS (C2BMC)

The Integration Research Area funds technological innovations related to supporting Command, Control, Battle management, and Communications (C2BMC). As such, C2BMC is the integrating element of the Ballistic Missile Defense System (BMDS).

MDA08-037	End-to-End BMDS Interceptor / Ground Terminal Communication Links
MDA08-038	Global Missile Defense Battle Management
MDA08-039	Discrimination
MDA08-040	Sensor Registration

INFORMATION ASSURANCE

The Information Assurance/Computer Network Defense (IA/CND) Research Area pursues cutting edge solutions to enhance the security posture of the Ballistic Missile Defense System (BMDS) and to explore new anti-tamper capabilities.

MDA08-041	Power Solutions for Integrated Anti-Tamper Technologies
MDA08-042	Real-time Application Security in a Communications Network
MDA08-043	Ballistic Missile Defense Anti-Tamper Penalty and Response Capabilities

SAFETY/INSENSITIVE MUNITIONS(IM)

The safety and Insensitive Munitions (IM) research area covers the overall safety of the Ballistic Missile Defense System (BMDS) and its components. The current focus of this research area is IM and missile propulsion safety including hypergolics and igniters. IM is a Department of Defense (DoD) requirement derived from U.S. law and addresses the need to minimize munitions' reactions to unplanned stimuli such as fire, bullet and fragment impact. IM is a major thrust area and priority throughout DoD, and, as a result, many new IM technology projects have been initiated. The other related area of research is overall safety improvements to Ballistic Missile Defense (BMD) systems. To date, activity in this area has concentrated on new guided missile igniter technology and safer hypergolic propellants for use in attitude control systems. The safety research area is governed by MDA program needs to meet military and NATO safety standards.

MDA08-044	Development of Fast and Slow Cook-off Mitigation Sensor
MDA08-045	MIL-STD-1901A Compliant In-Line Initiation Systems for Propulsion Applications
MDA08-046	Safety Technologies for Liquid Hypergolic Propulsion Systems

DIRECTED ENERGY

The ultimate Directed Energy Research Area technical objective is to take innovative technology developed by dynamic small businesses and insert the technology into air and ground weapon systems for integration into the Ballistic Missile Defense community.

MDA08-047	Compact High Power Microwave Payloads
MDA08-048	Improved Pressure Recovery System
MDA08-049	Advanced Light-Weight Solid State Laser Cooling System (High Power Solid State Laser)
MDA08-050	Passive Range Estimation from Angle-only Sensor Data (Acq Pointing & Tracking)
MDA08-051	Advanced LADAR Modeling

MDA SBIR 083 Topic Index

MDA08-001	Cabling Architecture and Mechanisms
MDA08-002	Interceptor Seekers
MDA08-003	Advanced Synergistic Structures for Interceptor Kill Vehicles
MDA08-004	Interceptor Guidance, Navigation, and Control (GNC) Algorithms
MDA08-005	Advanced Divert and Attitude Control Systems (DACS)
MDA08-006	Interceptor Avionics
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MDA08-013	Advanced Space Sensor Components and Concepts
MDA08-014	Radiation-Hardened Memory
MDA08-015	Real Time Monitoring of Natural and Enhanced Space Environments
MDA08-016	Spacecraft Assembly, Integration and Test Enhancement
MDA08-017	Silicon Carbide (SiC) Cryogenic Optics Technology Advancement
MDA08-018	Manufacturing Process Maturation for Propulsion Technology
MDA08-019	Improved Performance, More Producible Long Wave IR Integrated Dewar Assemblies
MDA08-020	Advanced Missile Materials and Process Technologies
MDA08-021	A Risk Reduction Process for Enhanced Mission Assurance
MDA08-022	Ballistic Missile Defense System Innovative Power
MDA08-023	Radiation Hardened Producible Manufacturing
MDA08-024	Advanced Nitride Heterostructures for X-Band GaN HEMTs
MDA08-025	High-Power RF-MEMS Phase Shifters for Phased-Array Applications
MDA08-026	Multistatic Sea-Based Radar Concepts and Architectures
MDA08-027	Wideband Beamformer
MDA08-028	Wideband Sub-Array Digital Receiver Exciter (DREX) Development and Packaging
MDA08-029	Wide Bandgap Semiconductor Power Inverters and Converters for Next Generation Transmit Receive (T/R) Module Power Supplies
MDA08-030	Calibration techniques for very large arrays
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MDA08-041	Power Solutions for Integrated Anti-Tamper Technologies
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MDA08-044	Development of Fast and Slow Cook-off Mitigation Sensor
MDA08-045	MIL-STD-1901A Compliant In-Line Initiation Systems for Propulsion Applications
MDA08-046	Safety Technologies for Liquid Hypergolic Propulsion Systems
MDA08-047	Compact High Power Microwave Payloads
MDA08-048	Improved Pressure Recovery System
MDA08-049	Advanced Light-Weight Solid State Laser Cooling System (High Power Solid State Laser)

MDA SBIR 083 Topic Descriptions

MDA08-001 TITLE: Cabling Architecture and Mechanisms

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

ACQUISITION PROGRAM: DE

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative approaches for reliable/ robust modular interconnection of interceptor components, including electrical,radio-frequency, heat, light and accommodating special needs (separation / pyro, EMI, lightning, weather).

DESCRIPTION: This topic seeks improvements to the means by which the components within an interceptor platform are united to form a coherent system. Canonically, the modular components of interceptors are mechanically affixed within the platform structure and joined together through electrical connectors. The platform provides structures for mechanical protection, electrical (digital/analog/radio-frequency/power) transport, and thermal management to these components. Conventionally, the platforms provide cabling between components through covered raceways, which may be internally potted for improved robustness. Traditionally, the overall wiring harness and fairing are fabricated as an integrated unit referred to as an integrated missile harness fairing assembly (IMHFA). We seek improvements to this classic architecture to include; the examination of integral modular structures, enhanced connectors, adaptive wiring, integrated self-test/diagnostic, enhanced test/debug support, advanced optical/rf approaches, and in general any improvements that lead to more rapid and flexible construction, integration, assembly, test, and deployment of cabling systems. We also seek innovation that can lead to the simplification of harnessing through embedded component intelligence, clever bandwidth exploitation/multiplexing of functions, and standard interfaces. Among the challenges faced by new approaches are: (1) mass/volume overhead of cabling, (2) mechanical robustness (harsh flight environments, storage, handling), (3) expanding performance, (4) resilience to aeroheating, (5) weather exposure/erosion, (6) lightning protection, (7) extreme temperature cycling, and (8) signal integrity. We are also interested in the critical interdependence of platform structures to cabling and component interfaces and additionally seek creative treatments of structures (e.g., use of composites). Proposers must also address separation systems, which pose special challenges.

PHASE I: Develop architecture concepts and requirements for test articles and objective vehicle articles. Develop raceway or IMHFA concepts or establish the equivalency of proposed concepts to these constructs. Develop a design and plan of approach for development of stated objectives. Through analysis, identify approaches for potential solutions to the above challenges that meet the challenges outlined above. To the degree possible, demonstrate and provide confidence in the approaches through test.

PHASE II: Develop prototypes of improved raceway(s) / IMHFA(s) (or equivalents) based on the Phase I effort that demonstrate proof of concept. We would expect the prototypes to be suitable to support static fire tests and flight tests, with appropriate full scale articles. The degree to which the offeror can partner with groups capable of supporting these demonstrations will help accelerate acceptance of such concepts.

PHASE III: Support further flight tests and provide design and fabrication techniques to support direct insertion of the technology into one or more missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Cabling and harnesses provide significant complexities in the development of many categories of commercial platforms. Innovative approaches in this topic will provide useful spin-off opportunities for commercial wiring harness designs.

REFERENCES:
1. Kautz, W.H., "Testing for Faults in Wiring Networks", IEEE Transactions on Computers, April 1974 (Vol. 23 No. 4): pp. 358-363.

2. Xie, Jingsong et.al. "An Investigation of the Mechanical Behavior of Conductive Elastomer Interconnects", Microelectronics Reliability 41(2001):281-286.

KEYWORDS: raceway, Integrated missile harness fairing assembly, Composites, EMI, Lightning strike, Thermal protection systems, Missile structures, Electrical connectors

MDA08-002 TITLE: Interceptor Seekers

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop and demonstrate highly integrated, compact, high performance, lightweight interceptor seeker technologies to include advanced active, passive and multi-mode seekers, sensors, and seeker components, for RF and EO/IR seekers. These technologies will be part of an integrated seeker suite and they will be used for insertion into spiral upgrades to current BMDS interceptor systems to enable advanced, agile interceptors to defeat various targets, facilitate discrimination, and defeat the asymmetric threat. A primary objective is for long range detection, tracking and intercept of all Ballistic Missile Defense (BMD) endo- and exo-atmospheric targets in all phases of flight, boost, midcourse and terminal.

DESCRIPTION: Key functions of a missile defense interceptor are to detect, track, discriminate, and engage threat objects. Those functions rely on seeker technology to measure line of sight angle, and in some cases, range and range rate, to intercept targets successfully. They may also measure discrimination data such as IR radiance in multiple bands, target images in several dimensions, and dynamics. Both active and passive seekers, and the combination of them in a gimbal or strapdown (preferred) configuration are critical for future discrimination seekers.

This topic calls for passive and active interceptor seekers and their components that will be able to detect, track, and discriminate targets at long ranges (greater than 1000Km) . For passive infrared seekers at 10 micrometer cutoff wavelengths, the following figure of merit should be met: the focal plane array format larger than 256 x256, pixel pitch less than or equal to 30 micrometers, median specific detectivity larger than 2x1011 cm Hz1/2/watt, uniformity larger than 96%, operability larger than 95%. Focal plane arrays operating at very long infrared with cutoff wavelengths up to 14 micron are also solicited with similar figures of merit. In addition, innovations are sought after for pixel-coregistered multi-band focal plane arrays that have two to four wavebands, i.e., MW/LW, LW/LW+VIS, LW/VLW or MW/LW/LW. Novel ideas in advanced readout circuit are encouraged to address radiation hardness, e.g., Gamma circumvention. Active strapdown seekers to include laser ranger, laser radar and RF, are also to be considered. The innovative concepts, components and technologies to be developed under this topic include multi-mode active/passive seekers and their components, on FPA and near FPA data processing, data rate reduction, and dual Field of View lenses (to enable zoomable lens).

Improvements are also sought for interceptor light-weight, compact, strapdown active seeker components. Technologies are sought to substantially advance the performance of line of sight pointing systems, achieving >+/-60 degrees steering with stable submillisecond response across the field of regard. System accuracy should be able to achieve stable microradian accuracy within the period of response. Volume constrains are in the order of 500mL, and stable operation in vacuum is required. Transmitters with chip-scale-packaging, scalable sources for increased ranging are needed. Compact and efficient fiber sources and integrated systems through advances in slab and solid state lasers demonstrating high power efficiency are also sought. Thermal management and advanced packaging methods are needed to prevent system drift and avoid component instability. Heat removal from advanced electronic processors, cryogenic detectors, laser pump diode sources, require power and cost efficient systems meeting ground test and short mission objectives. Compact cooling systems, heat removal and thermal storage technologies suitable for space environments are desired. Innovations in small, low cost, rugged, high-power RF seekers and RF seeker components are also sought for millimeter and shorter wavelengths. Technology improvements are needed in lightweight, high efficiency solid-state or tube sources, frequency combiners, radomes, antenna design, and integrated electronics. Pulsed radar techniques such as coupled oscillator beam steering, and pulse compression in order to realize low cost, compact antennas with maximum resolution are of interest.

PHASE I: Research, quantitatively analyze, and develop a conceptual design and assess the feasibility of an active, passive, or multi-mode seeker system or component. In the case of a component it is desirable (budget permitting) that a prototype be developed and demonstrated.

PHASE II: Design, develop, and characterize a prototype of the active, passive, or multi-mode seeker system (or component) and demonstrate its functionality. Investigate private sector applications along with military uses of key components developed in Phase II.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:
1. W. Dyer, W. Reeves, and G. Dezenberg, “The Advanced Discriminating Interceptor”, AIAA Missile Science Conference Proceedings, 1994.

2. M. Skolnik, “Radar Handbook”, McGraw-Hill, 1990.

3. M. Z. Tidrow, “MDA Infrared Sensor Technology Program and Applications”, SPIE Proceedings Vol 5074 (2003), p 39.

4. J. L. Miller, Principles of Infrared Technology, Chapman & Hall, 1994.

5. A. V. Jelalian, Laser Radar Systems, Artech House, Inc., 1992.

6. J.S.Acceta and D.L. Shumaker, “The infrared and electro-optical systems handbook”, SPIE Optical Engineer-ing Press, Bellingham, Washington, 1993.

7. Sood, A. K., et. al., “Design and development of multicolor detector arrays,” Proc. SPIE, Vol. 5564, p. 27-33.

8. Dhar, N. K. and Tidrow, M. Z., “Large format IRFPA development on Silicon,” Proc. SPIE, Vol. 5564, p. 34-43.

9. Trew, R J, “SiC and GaN Transistors—Is There One Winner for Microwave Power Applications?”, Proceedings of the IEEE, June 2002, Vol. 90, Issue 6, pp1032-1047.

KEYWORDS: Remote Sensing, Multispectral Imaging, Discrimination, IR Detectors, Spectral Characteristics of Materials

MDA08-003 TITLE: Advanced Synergistic Structures for Interceptor Kill Vehicles

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop technology for an interceptor Kill Vehicle (KV) that integrates disparate components into the load bearing structure to increase the performance of the KV.

DESCRIPTION: The phrase "Synergistic Structures" in this context refers to Structures with multiple functions (e.g., fuel tanks or batteries that function as load-bearing KV structure and/or protect against hostile environment) or structures with embedded components (e.g., electrical, optical, power, cabling, propulsion, sub-structures, isolation, etc). The synergy must not compromise the integrity of the interceptor. The MDA has funded numerous technology development programs that could be applied toward KVs. However, many of these efforts focused on an individual component without the consideration of combining components into a system to save mass, volume, and ensure structural integrity. The MDA is interested in developing revolutionary and evolutionary KV technologies that will significantly improve key performance parameters (speed, volume, mass, accuracy, agility, etc.). In recent years, a number of new technologies have emerged (new materials, nano-research, component/electronic miniaturization, enhanced kill effects, etc.) that make it feasible to integrate components in a system without degradation of other subsystems. This effort will focus on the development of embedded components of previously independent structures/subsystems with considerations to the following: radiation shielding, structural stability, harmonics, mass, reduced part count, enhanced lethality, and reduced volume. Additionally, the structural system must be designed to the operational environment (temperature variations, high acoustic levels, maneuvering loads, high shock loads, HAENS level 2, and severe vibration loads). Proposals should provide sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with the concept and describe the system-level benefits.

PHASE I: Develop initial design concept; conduct analytical and experimental efforts to demonstrate proof-of-principle; develop preliminary design complete with documentation that will provide proof-of-functionality; and model or produce/demonstrate "breadboard operational prototype" to ensure proof of basic design concept. Proposed concepts should be modeled with representative KV-type environment. The contractor will provide any embedded components for models, breadboards, etc. Simulated embedded components may be substituted for actual components if their use is substantiated by analyses. The contractor will develop a Phase II strategy plan that includes (but not limited to) development and integration strategy, potential demonstration opportunities, program schedule, and estimated costs.

PHASE II: Design and fabricate a prototype structural concept that could be demonstrated in a representative KV environment. The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors. The contractor will provide any embedded components for prototypes.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing. The contractor will provide any embedded components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for highly integrated/synergistic structures is immense in the aerospace, automobile, and infrastructure industries.

REFERENCES:

1. Starr, A.F., et al., “Fabrication and Characterization of a Negative-Index Composite Metamaterial,” Physical Review B, Vol. 70, 113102 (2004).

2. Adams, J.H., “Radiation Shielding Materials,” AIAA 2001-0326, 39th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, 8 January 2001.

3. Wilson, J.W., et al, “E-Beam-Cure Fabrication Polymer Fiber/Matrix Composites for Multifunctional Radiation Shielding,” AIAA 2004-6029, Space 2004 Conference and Exhibit, San Diego, CA, 28-30 September 2004.

4. Thostenson, E.T., Ren, Z, Chou T-W, “Advances in the science and technology of carbon nanotubes and their composite: a review” Composites Science and Technology, 61, pages 1899-1912, 2001.

5. Ruffin, P. B. “Nanotechnology for Missiles” Quantum Sensing and Nanophotonic Devices, Proc. Of SPIE, Vol. 5359, Bellingham WA, 2004.

KEYWORDS: Synergistic Structures, Integrated Structures, Kill Vehicles, Radiation Shielding, Communications, Optics, Composite Materials, Nano-Materials

MDA08-004 TITLE: Interceptor Guidance, Navigation, and Control (GNC) Algorithms

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This SBIR topic will seek development and demonstration of: a) advanced Guidance, Navigation, and Control (GNC) kill vehicle (KV) algorithms with emphasis on engaging maneuvering targets during boost, midcourse, or terminal phase of their flight and, b) Multiple Kill Vehicle (MKV) weapon-target assignment and collision avoidance algorithms for enhanced interceptor KV agility and guidance flexibility. Performance goals include the minimization of interceptor control energy, miss distance, and reliance on a priori data.

DESCRIPTION: GNC algorithms include interceptor and KV guidance algorithms (including estimators, guidance laws, and controllers) for kinetic kill intercept, especially against advanced maneuvering threats. Threat trajectory uncertainty due to maneuvering capability could stress our interceptor’s response time and maneuverability requirements.

The objective of this topic is to demonstrate novel algorithms in the following areas, in order of priority:
(1) estimation, (2) guidance, and (3) control for a specified missile concept. Responses may concentrate in any one of the areas or preferably provide an integrated approach. Algorithms that enhance the probability of successful kill-vehicle (weapon)-to-target paring for multiple kill vehicle missiles are desired as are also algorithms to defend against maneuvering targets during all phases of the engagement time line. Algorithms should support dual sensor systems, such as combined passive and active seeker kill-vehicles.

Proposed algorithm design methodologies must start with a configuration description and technical specifications for the kill-vehicle, sensors, and actuators. The design methodologies must incorporate any novel approaches into an integrated design including the various missile components.

PHASE I: Develop algorithms that will provide a high probability of kill against maneuvering threats. Demonstrate algorithm performance in an integrated, Model and Simulation environment of sufficient fidelity.

PHASE II: Optimize results of Phase I, evaluate and mature algorithms developed in Phase I in a 6-DOF test bed, and validate the algorithms in real time hardware in the loop facilities. The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors

PHASE III: The algorithms developed under the Phase II effort will be inserted the acquisition process for missile defense systems. Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their effort, and to work towards technology transition

PRIVATE SECTOR COMMERCIAL POTENTIAL: Advanced non-linear GNC algorithm development has applications in the commercial airline industry, unmanned aerial vehicles, robotics, rotorcrafts, etc.

REFERENCES:

1. Dyer, W. R., “Boost Phase Homing Guidance,” 2003 Multinational Ballistic Missile Defense Conference, 2003.

2. P. Zarchan, D. Lianos “Filtering Strategies for Spiraling Targets” Proceedings of the 9th AIAA/BMDO Technology Conference, 2000.

3. R. Chen, J. Speyer, D. Lianos “ Homing Missile Guidance and Estimation under Agile Target Acceleration” Proceedings of the AIAA Guidance, Navigation and Control Conference, 2006.

4. Ben-Asher, Yaseh, Advances in Missile Guidance Theory, AIAA, 1998.

5. Zarchan P., Tactical and Strategic Missile Guidance, 3rd Edition, AIAA, 1997.

6. Chadwick, W. R., “Reentry Flight Dynamics of a Non-Separating Tactical Ballistic Missile,” Proceedings of AIAA/BMDO Interceptor Technology Conference, San Diego, CA, 1994.

7. Zarchan, P., “Proportional Navigation and Weaving Targets,” Journal of Guidance, Control, and Dynamics, Vol. 18, No. 5, 1995, pp. 969-974.

8. Cloutier, J. R., D¡¦Souza, C. N., and Mracek, C. P., “Nonlinear Regulation and Nonlinear HInfinity Control Via the State-Dependent Riccati Equation Technique,” Proceedings of the International Conference on Nonlinear Problems in Aviation and Aerospace, Daytona Beach, FL, May 1996.

9. Mracek, C.P. and Cloutier, J.R., “Missile Longitudinal Autopilot Design using the State Dependent Riccati Equation Method,” Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.

10. Cloutier, J.R., “State-Dependent Riccati Equation Techniques: An Overview,” Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.

11. Xin, M., Balakrishnan, S. N., and Ohlmeyer, E. J., “Nonlinear Missile Autopilot Design with Theta-D Technique,” AIAA Journal of Guidance, Control and Dynamics, Vol. 27, No. 3, May-June 2004.

12. Menon, P. K. and Ohlmeyer, E. J., “Computer-Aided Synthesis of Nonlinear Autopilots for Missiles,” Journal of Non-linear Studies - Special Issue on Control in Defense Systems, Vol. 11, No. 2, 2004.

13. Menon, P. K., Sweriduk, G. D. and Ohlmeyer, E. J., “Optimal Fixed-Interval Integrated Guidance-Control Laws for Hit-to-Kill Missiles,” AIAA Guidance, Navigation and Control Conference, Austin, TX, 11-14 August, 2003.

14. Menon, P. K. and Ohlmeyer, E. J., “Nonlinear Integrated Guidance-Control Laws for Homing Missiles,” AIAA Guidance, Navigation & Control Conference, Montreal, Canada, 6-9 August, 2001.

15. Menon, P. K. and Ohlmeyer, E. J., “Integrated Design of Agile Missile Guidance and Control Systems,” IFAC Journal of Control Engineering Practice, Special Issue on Control in Defense Systems, Vol. 9, 2001.

KEYWORDS: control algorithms, estimation, guidance, data processing, flight control, interceptors, neural network, optimal control, navigation

MDA08-005 TITLE: Advanced Divert and Attitude Control Systems (DACS)

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

ACQUISITION PROGRAM: DV

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OBJECTIVE: Develop and demonstrate advanced solid/liquid interceptor DACS components and systems for atmospheric/exo-atmospheric use, operational at the ambient temperature (-60 Deg F to 170 deg F). Criteria include low cost (<$200K), light weight (<10 Kg including fuel with delta V > 1,000 m/sec), high performance, fast reaction (<10 ms), and resistance to high temperature (2500 degrees C) and high pressure (2000 psi) with minimum out-gassing. Novel concepts for lightweight DACS with high delta velocity (> 1,000 m/sec) and high thrust (>> 5 gs) that enable large mass fraction (> 40% system mass fraction and 60% DACS mass fraction) are of special interest. The life expectancy of the all-up round >10 yrs.

DESCRIPTION: Advanced DACS technologies are needed to address cost reduction, insensitive munitions and safety requirements, while maximizing the kill vehicle (KV) divert capability and/or reducing the KV weight within restricted geometries. Advanced solid and liquid propellants that provide improved performance and reduced environmental impacts are needed with high density-specific impulse products. The increased combustion temperatures (>2500 degrees C) associated with advanced solid and liquid propulsion require more robust materials and processes, and propulsion systems with lifetimes commensurate with interceptor system operational requirements. Advanced techniques for propulsion components, such as nanotechnology, and materials such as carbon matrix composites, ceramic matrix composites, cermets, and refractory metals to increase the operating temperature, reduce oxidation and erosion are sought. Desired materials include both composite and monolithic. In addition to temperature resistant materials, techniques for cooling components are needed (provided they are compatible with a light weight, low cost DACS). Proposals that address survivability of propulsion electronics in an interceptor radiation environment are also sought, especially for DACS electronics.

Despite recent progress, several technical propulsion challenges remain, including, but not limited to:
• Understanding the compatibility of ablative composites (tank/seal) materials in green & non-green liquid propellant environment (HAN, ADN, Hydrazine…).
• Demonstration of complex braided structures and integral assemblies for green & non-green liquid mono-propellants specific hardware.
• Enhanced matrix compositions that improve life for oxidizing environments at 2500 deg C and beyond to exploit emerging high performance propellant formulations.

Additional technologies of interest to the topic also include: monolithic SiC or silicon thrusters using liquid or gel propellants; colloidal thrusters; phase change solid –to-gas or liquid-to-gas electro-thermal thrusters, innovative bi-propellant or monopropellant concepts; solid propellant multi-pulse or breech concepts; pulse detonation rocket engines; micro/MEMS propellant valves.

PHASE I: Develop a design and a plan of approach for development for above stated objectives. Through analysis and M&S, identify approaches for potential solutions to the above listed challenges.

PHASE II: Implement one of the promising approaches identified during phase I. Fabricate a prototype that demonstrates the proof of concept. The demonstration should include materials compatibility at or above 2500Deg

C. Offerrors are strongly encouraged to align their effort towards a relevant BMDS system and payload contractors to ensure technology transition.

PHASE III: The developed technology should have direct insertion potential into missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic should have applicability to automobile industry, unmanned vehicles etc.

REFERENCES:

1. George P. Sutton, “Rocket propulsion Elements; Introduction to Engineering of Rockets” 7th edition, John Willey &Sons, 2001.

2. Paschal N, Strickland B, Lianos D, “ Miniature Kill Vehicle Program”, 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.

3. Vigor Yang, Thomas B. Brill, and Wu-Zhen Ren, “Solid Propellant Chemistry, Combustion, and Motor Interior Ballistics”, AIAA, 2000.

4. Murthy S.N., Curran E.T, “Development in High Speed Vehicle Propulsion Systems, AIAA, 1996.

5. G. Hagemann, H. Immich, T. Nguyen “Advanced Rocket Nozzles” Journal of Propulsion and Power , Vol 14, No 5, pp620-634, AIAA, 1998.

6. Handbook of Radiation Effects, 2nd Edition, Chapter 7, A. Holmes-Siedle and Len Adams, Oxford University Press, 2002.

KEYWORDS: Solid propellants, liquid propellants, DACS, Actuator, Hot gas generator, HAN

MDA08-006 TITLE: Interceptor Avionics

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DV

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OBJECTIVE: The objective of this research and development effort is to encourage the genesis of innovative, high performance avionics systems, subsystems, and components that will enhance the capability of current and future interceptors in a hostile environment.

DESCRIPTION: Avionic systems currently used in the BMDS interceptors are too expensive, bulky, and heavy. They provide limited bandwidth, power, and range and are sensitive to shock and vibration. Next generation interceptor designs will demand further performance enhancements to support new missions while simultaneously reducing weight and power dissipation. Interceptor Avionics, for this topic, includes the seeker signal/image processors, flight computer, gyros, accelerometers, associated electronics and their integrated units (Inertial Reference Unit, Inertial Measurement Unit), with or without Global Positioning System augmentation, secure interceptor communication system (with or without implementation of Software Defined Radio (SDR) solutions), internal wiring/wireless interconnectivity, connectors, networks, and interceptor power sources and conditioning. Improvements in the avionics data transmission, power generation/distribution, processing, and system architecture are required to enable interceptor advancements. Disparate interface designs, incompatible components and subsystems are barriers to efficient, cost effective design of integrated interceptor avionic systems. Standardization of interceptor avionics through plug and play paradigm are sought after.

Large format, multi-color seekers may require more than 100 million pixels per second, and will benefit from any technology that would reduce that demand through on-focal plane processing or intelligent, flexible data compression hardware/firmware. Proposed designs should strive to double the existing performance at half the cost. Therefore, performance goals for the advanced designs should be in the range of 20-200 mega pixels per second, with processor speeds in the multi-gigahertz range, IMU data rates in the 20 kHz range, and a cost target under 25% of overall missile cost. Furthermore, as interceptor systems upgrade toward longer-range capabilities along with increasing requirements for agility, processing power, and accuracy, a new GNC modular architecture, along with compact, inexpensive, advanced GNC components is needed. In addition, as the interceptor migrates toward a more flexible and agile vehicle, the size, weight, and performance requirements of the GNC components will be more challenging and capability for external navigation updates such as GPS are needed. This SBIR topic also solicits novel concepts and technologies in making GNC components (gyros, accelerometers, associated electronics etc.) low in cost, lightweight, compact, and of high performance. These technologies and the integrated package should have the architectural capability to easily change to suit the interceptor in which they will be used. The desired performance goals to guide the research are drift rates on the order of 0.1-2 deg/hr, gyro noise on the order of 0.1-0.002 deg/rt-hr, and data rates and bandwidths of multiple kHz to as high as 20 kHz. Weight for the overall system should be much less than 400 grams with volume much less than 30 cu. in, and a substantial cost reduction compared to existing GNCs. The GNC components and integrated system must be able to withstand high shock and vibration upon missile lift-off and separation events, and during DACS operation, impose minimum operational requirements prior to launch, and operate in a thermal environment from -50 C to + 70 C. They should not be sensitive to Electro-magnetic Interference or prolonged storage at the above temperatures. Radiation hardness to >300krad is desirable. Capability for ten years of dormancy prior to launch is desirable. An integrated GPS receiver is desired to provide greater flexibility in launcher placement, improved guidance accuracy, and integrated operations, but the GNC suite should also be able to operate autonomously in a GPS-denial environment.

A significant need also exists for enhanced, highly reliable, high speed, in-flight communications between the Ballistic Missile Defense System (BMDS) Fire Control and Interceptor/Kill Vehicles) in an operational fading channel environment potentially perturbed by nuclear weapons effects Any proposed communications schemes must be scaleable as Missile Defense architectures grow in both geographic coverage (locations & platforms) and in hardware (number and type of interceptors or kill vehicles). Duplex communication adhoc communication links between Communication Ground Terminal, Interceptor Platform, and Satellite Platforms should be considered. Advanced secure interceptor communication systems (<200 grams and 3”x2”x0.5” in size) will be required for future systems. Interceptor communications must be able to transmit in radiation environments and establish link (s) within 50 km with peak transmission power of <5 Watts. They must also be able to receive updates at ranges up to 1000 km.

Methods to improve interceptor diagnostics/prognostics within avionics architecture are solicited. Additionally, internal data busses, cabling, and connectors are sources functional faults. Access to and checkout of these avionics components is important Elimination of cables and connectors via wireless connectivity is also desirable.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance avionics performance. Determine expected performance through extensive analysis/modeling effort. Identify technical risks for the avionics and subsystems and develop a risk mitigation plan. Proposed designs should strive for twice the performance of current technology at half the cost, and strongly suggest a growth opportunity for further performance increases and cost reduction.

PHASE II: Design, develop and characterize prototypes of the proposed technologies and demonstrate functionality. Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop and execute a plan to manufacture the avionics system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed avionics technology growth areas would have applicability to automobile industry, communication satellites, the computer industry, cell-phone industry, airline communications, and over-the-air communications. Other efforts within the DoD are focused on two-way data links to weapons systems and relevant technology from this effort will be transferred to those programs. The contractor will pursue commercialization of the proposed technologies in the fields of munitions and missile guidance, instrumentation for motion control, simulation & training, vehicle safety and personal navigation

REFERENCES:

1. H.Helvajian, “Microengineering Aerospace Systems” The Aerospace Press, American Institute of Aeronautics and Astronautics, 1999.

2. Rebeiz, Gabriel M. RF MEMS Theory, Design and Technology. John Wiley & Sons, Inc. Hoboken, New Jersey, 2003.

3. S. Lyshevski, “MEMS and NEMS, systems, devices and structures”, CRC Pres, 2002.

4. P.Zarchan, Tactical and Strategic Missile Guidance, 3rd Edition, AIAA, 1997.

5. J. Soderkvist, “Micromachined Gyroscopes” 7th ICSS Sensors Actua., pp. 638-41, 1994.

6. R. Dorf, Modern Control Systems 6th Edition, Addison Wesley, 1992.

7. Digital Communications in Fading Channels: Modulation and Coding, R. L. Bogusch. Mission Research Corp., Report for Air Force Weapons Lab, Kirtland Air Force Base, NM, 1989.

8. DARPA Tactical Targeting and Network Technology (TTNT) program http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9.

9. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.

10. Valenti, M.C., E. Hueffmeirer, R.L. Bogusch and J. Fryer, “Towards the capacity of noncoherent orthogonal modulation: BICM-ID for turbo coded NFSK, Proceedings of the IEEE Military Communication Conference (MILCOM), November 2004, pp. 1549-1555.

KEYWORDS: interceptor, avionics, gyros, accelerometer, communication, power, signal processors, data processors, electronics, communications architecture, jamming, high altitude nuclear explosions, RF data link.

MDA08-007 TITLE: Innovative Axial Propulsion Technology for Missile Defense Interceptors

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DV

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OBJECTIVE: Develop innovative booster component designs and test capabilities, suitable for use in BMDS interceptors, that are: low cost, highly reliable, cognizant of DoD insensitive munitions (IM) objectives compliant, stable in long term silo storage and/or mobile systems, tolerant of many sea level to high altitude environmental cycles, capable of Thrust Vector Control (TVC) and variable thrust, require minimal maintenance and they have non-destructive integrity inspection / test features.

DESCRIPTION: Increased kill mechanism velocity and increased missile block speed is desired to provide increased battlespace for operations with off-board sensors, to address advance threats and degraded or alternate sensor handover capability. Specific areas of interest are:
• Propellant chemistry - including advanced liquid monopropellant, bipropellant and HTPB propellant formulations to improve specific impulse and density impulse and with improved cold temperature operation and storage capability; age-life projection and non-contact or in-situ aging monitoring.
• Motor case technology - high strength, high stiffness and lightweight polymer matrix or metal matrix composite cases and liner/insulation materials and processes. Improvements in producibility and affordability; cases with integral cable raceways. Consumable flexible (EPDM like) insulator materials with near zero particulates and residual char.
• Ceramic Matrix Composite (CMC) materials technology – high strength, oxidation and erosion resistant, and lightweight CMC material compact, complex, and cost effective net shape manufacture techniques are sought for applications to propulsion system components that include consideration of CMC to metal joining
• Nozzles- refractory ultra-high temperature materials for non-eroding throats; novel materials and designs for exit cones with decreased processing schedules and lower cost.
• Integral vehicle health monitoring - research into technologies related to "cradle-to-grave" monitoring of solid rocket motor cases, including sensors, fiber optics or conventional wiring, readout electronics, and diagnostic or prognostic software/hardware.
• Ignition safety – The prevention of unintended ignition with 1901A compliant ignition systems.
• Thrust Vector Control technologies – High vectoring magnitude and response capability at reduced system power, mass, and volume footprint.
• Manufacturing Processes – Implementation of Design for Manufacturability and Assembly (DFMA) to include overall solid propellant motor/booster integration. Lightweight mandrel development for graphite composite and metal impregnated fiber cases; Improvements in refractory material processing and affordability.
• Interceptor stage separation – Innovative solutions are sought to simulate pre and post separation control effects of hypersonic missiles conducting a booster stage separation function at low altitude. Solutions to capture the dynamic nature of the staging event are desired.
• Jet Interaction Control – Simulations to determine aerodynamic and jet interaction control effects over the airframe of a hypersonic interceptor booster is desired.

PHASE I: Identify candidate materials, designs, and/or test capabilities. Fabricate and characterize materials for component technologies. For propellant improvements, conduct research and experimental efforts to quantify specific impulse, mass fraction, long term storage compatibility and / or cyclic environmental load capabilities of the investigated propellants, and IM compliance.

PHASE II: Develop and demonstrate prototype designs of Phase I booster propellant and/or components in a test environment. Develop and document designs and/or test approaches. Perform appropriate characterization and testing, e.g. sub-scale motor tests, accelerated long term storage and / or cyclic environmental load compatibility testing, and IM related testing such as fast and slow cook-off. A partnership with the current or potential supplier of BMDS element systems, subsystems, or components is highly desirable. Identify any commercial application of technology or opportunities of benefit from using the innovation.

PHASE III: Conduct engineering and manufacturing development, test and evaluation and hardware qualification. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed with insertion planning for a missile defense interceptor.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Axial rocket and missile propulsion technology has direct applicability to DoD, commercial and NASA launch capability. Component technologies, e.g. high temperature materials, can have broad industrial application in chemical processing, energy production and manufacturing.

REFERENCES:
1. George P. Sutton, “Rocked Propulsion Elements: an introduction to the engineering of rockets.” 7th Edition, John Wiley & Sons, 2001.

2. Palaszewski, Bryan, ‘Propellant Technologies: A Persuasive Wave of Future Propulsion Benefits’, NASA Glenn Research Center, Cleveland, OH, Feb. 1997., http://sbir.grc.nasa.gov/launch/Propellant.htm.

3. US DoD Insensitive Munitions Program Anthony J. Melita, http://www.dtic.mil/ndia/2003gun/mel.pdf

KEYWORDS: propulsion, materials, chemical compatibility, propellants, insensitive munitions

MDA08-008 TITLE: Target Instrumentation Technology

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: TC

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop and demonstrate highly integrated instrumentation both on and off-board targets that can be used to determine position of hit and attributes of hit and misses for kinetic and/or directed energy weapons.

DESCRIPTION: The Missile Defense Agency (MDA) seeks to lower the complexity and cost of instrumentation systems utilized on targets missiles while increase their capability and reduce impact to offboard and on-board systems. Avionics and instrumentation systems of current missile systems utilize standard temperature, pressure, etc. sensors that require sensor devices, wiring and data acquisition systems qualified to flight environments. Current instrumentation systems require high amounts of electrical power relative to other avionics systems and therefore increase the weight, cost and complexity of these systems. Development of miniaturized digital sensor systems for shock, vibration, temperature, and pressure that incorporate localized signal conditioning and digitization of sensor information and utilize lightweight data communications to centralize the data collection will enable significant simplification of missile-wide instrumentation signal conditioning and reduce missile power requirements. This topic seeks to develop affordable sensors that have the previously mentioned attributes, and capable of operating in the following ranges:

Sensor Type	Typical Application	Range	Units	Sampling Rate
Thermocouple/RTD	Avionics box Temp.	-60 to 120	°F	1 hz
Pressure transducer	Hydraulic monitor	0 to 500	PSI	200 hz
Accelerometer high range	Bulkhead shock	10-2000	Gs	8000 hz
Accelerometer low range	Axial acceleration	0-150	Gs	1200 hz
Discretes	Flight Computer	0-40	Vdc	20 hz
Voltage	Power Distribution Unit	0-40	Vdc	400 hz
Current	Power Distribution Unit	0-20	Amps	400 hz

In addition, current target lethality hit grids use an associated electronics package and S-band telemetry transmitter that consist of multiple electrical components, extensive cabling with large connectors, and require significant in-flight electrical power. The available space on current and projected MDA target objects to house the assembly is extremely limited and subject to center-of-gravity constraints. The number of electrical components in the assembly causes the assembly-level predicted reliability to be lower than desired. Sources are sought that will develop a miniaturized hit grid package (encoder and grid interface) that will reduce the overall footprint, interconnect cabling and weight required for the system. Sources are sought that demonstrate use of connectors and packaging to a PC/104 form factor and have a footprint of no greater than 43 square inches and weigh no greater than 6 lbf. The new development shall feature a standard serial interface port for optimization of data format and rate (up to

20Mbps) to support mission requirements. The hit grid package is to also contain an integral, high-efficiency telemetry transmitter capable of being programmed to operate in either upper or lower S-band, or upper or lower L-band to address potential bandwidth and link margin issues due to high bit rates. The transmitter is to draw no greater than 1.6Adc with a minimum power output of 10 watts. The transmitter is also required to utilize a more efficient modulation methods such as FQPSK or SOQPSK to reduce the amount of bandwidth required for the data link.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principal of the proposed technologies to enhance the targets instrumentation systems. Develop preliminary digital and deliver recommendations including manufacturers data sheets on recommended products in a final report. Perform preliminary design of bench-test proof-of-concept hit grid electronics.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop and execute a plan to manufacture the proposed electronics system, or components developed in Phase II and assist MDA in transitioning this technology to the appropriate prime contractors for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic have additional applicability to all intercept targets used for MDA element tests and to follow-on Operational Test & Evaluation intercept tests. Technologies would have applicability to the automobile industry, computer industry and communication satellites.

REFERENCES:
1. http://www.mda.mil/mdalink/html/basics.html

2. E. Fleeman, Tactical Missile Design, AIAA Education Series, 2001.

3. B.E.Noltinqk, Instrumentation Reference Book, Dec. 1988.

KEYWORDS: Targets, Instrumentation, electronics, grid, digital, sensor

MDA08-009 TITLE: Test Methodology and Equipment for Radiation Hardened Interceptors

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: DEP

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This effort seeks to improve test techniques, methodologies and/or equipment required to evaluate and/or validate radiation-hardened MDA systems and subsystems in realistic radiation environments. The radiation evaluation of interest includes subsystems such as focal plane array (FPA), sensor, optical components, telescope, signal processing, and control electronics (including components and materials where most cost effective), as well as radiation environment mitigation approaches. This topic applies equally to innovative upgrades to existing test systems (e.g. Air Force Research Laboratory's Kinetic Hardware In the Loop Simulators including their Nuclear Infrared Clutter Simulator / Nuclear Optical Dynamic Display System or Arnold Engineering Development Center's 10V and Portable Optical Sensor Test chambers) or new characterization concepts.

DESCRIPTION: Radiation-hardened MDA systems must function reliably when exposed to radiation from space and nuclear events. Non-structural shielding is generally weight-prohibitive in these systems. Test environments include, but are not limited to, x-ray, prompt and persistent gamma, single event effects, total ionizing dose, natural space radiation, scintillation and optical flash. Furthermore, such systems must be realistically tested at the component, sub-system and where possible, system level both for survival and operability. This effort seeks innovative methodologies to test and/or combine sub-system test results, leading to system performance evaluation in adverse radiation environments. MDA's goal is to support insertion of improved hardened technology within its systems with radiation hardening requirements. Technical areas of interest include: test methods and hardware, concepts that enable system operability while controlling degradation, and production concepts that reduce net costs of hardening efforts. This topic's focus is on innovations that can improve verification of missile defense radiation performance.

PHASE I: Demonstrate the feasibility of new and innovative concepts that address radiation test and evaluation of subsystems that support one or more elements of the BMDS. Devise techniques to validate reliable operation of the BMDS system for its radiation environments. Demonstrate the concept(s) can support evaluation of test object impact on system cost, mass and producibility. Explore the ability of the concept to support existing modeling, simulation, and analysis (e.g. does a single event technique support CREME-96?). Consider cost-effective and practical implementation of proposed concepts. It is anticipated that most proposals will only deal with a single radiation environment, but concepts that reduce total test burden or increase throughput are highly sought.

PHASE II: Develop the concept(s) from Phase 1 into experimental (or better) hardware/techniques. Implement, test and verify the proposed concept in a prototype to demonstrate feasibility and efficacy (within Phase II constraints). Demonstrate the concept addresses reliable operation of BMDS interceptors in perturbed environments consistent with nuclear detonations as described in Reference 2 as well as the natural space radiation. Develop experimental approaches that demonstrate the sensor radiation hardness capability. The approach must support a wide range of BMDS designs. Validation would include, but not be limited to, BMDS simulations, operation in test-beds, operation in a demonstration sub-system, and/or radiation testing. Offerors are encouraged to interact with system and payload contractors and test providers to help ensure relevance of their efforts and begin work towards technology transition.

PHASE III: In this phase, the contractor will produce components to fully comply with the established requirements to evaluate and/or validate MDA interceptor and DoD systems, or commercial applications. The degree to which the Offeror can attract suppliers to their solution is a strong consideration in gauging viability of the approach. The Offerors should pursue funded (if possible) co-support from system primes (and their subcontractors), as these are strong indicators of relevance of the proposed work. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end the Offerors are encouraged to further seek partnerships with system primes or interceptor vendors as appropriate.

PRIVATE SECTOR COMMERCIAL POTENTIAL: All work from this topic should apply to test of the larger class of satellite and missile systems and subsystems, which include commercial satellites and launch vehicles. Ground systems are experiencing single-event upsets at sea-level, and some test techniques developed herein may provide solutions for terrestrial systems, particularly high-reliability systems, whose failure has life-and-death consequences.

REFERENCES:
1. http://www.mda.mil/mdalink/html/basics.html.

2. Glastone, Samuel, The Effects of Nuclear Weapons, USAEC, USGPO, Washington D.C., 1957.

3. Kinetic Kill Vehicle Hardware-in-the-Loop Simulator (KHILS), http://www.afrl.af.mil/successstories/2005/support_war/MN-S-05-01_New.pdf

4. Flynn, Marlow, Kircher, Glattke, Murrer and Weir, "Development of a 2-color projection system for the KHILS Vacuum Cold Chamber (KVACC)", Technologies for Synthetic Environments: Hardware-in-the-loop Testing V, SPIE Vol. 4027, 2000.

5. Goldsmith, Herald, Erickson, Irvine, Mackin, Bryant, and Lindberg, "Setting the PACE in IRSP: A reconfigurable PC-based array control electronics system for infrared scene projection", Technologies for Synthetic Environments: Hardware-in-the-loop Testing VIII, SPIE Vol. 5092, 2003.

6. Flynn, Sisko, Sieglinger and Thompson, "Radiometrically calibrating spectrally coupled two-color projectors", Technologies for Synthetic Environments: Hardware-in-the-loop Testing VIII, SPIE Vol. 5092, 2003.

7. 3. G.C. Messenger and M.S. Ash. The Effects of Radiation on Electronic Systems. Van Nostrand Reinhold, New York, 1986.

KEYWORDS: radiation effects on electronics, radiation hardening, sensors, hardware test methods

MDA08-010 TITLE: Improved Cryogenic Cooling Technology

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons
ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve jitter, mass, and/or power performance for electro-optical (EO) space payloads by improving performance of components of the cryocooling system. These performance improvements (in rough priority order) may consist of: a reduction in weight of or power consumption of the cryocooling system; an improvement in heat transfer to, within and/or from the cryocooling system; enabling the transfer of cooling across a gimbal, a flexible joint, and/or to multiple payloads from a single cooler; an ability of the cooling system to rebalance loads vs. temperatures over system life; a reduction in the jitter induced by the cooling system.

DESCRIPTION: Next generation missile midcourse detection infrared sensing technologies and on-board cryogenic cooling needs will require improvements in component level technology that reduce payload jitter, mass, and power budgets through improved thermal management of cooling loads and rejected heat. The issues associated with gimbaled sensor systems are of particular interest. Specific areas of interest are: application of improved heat conduction materials (e.g. composites with anisotropic conductance or conductances greatly above those of pure elements) to cooler or heat transport components; pumped or wicked cryogenic cooling load transfer devices capable of transferring significant (2-10 W) cooling loads across a two axis gimbal, flexible join, or to multiple locations on a spacecraft; cryocooler component improvements, thermal control devices for high density microcircuits, and the control electronics associated with any active devices. All devices must be capable of 10 years operation in a space environment, including 300Krad total dose of radiation (ionizing and proton).

Some notional system within which the improved component will operate must be described. The nominal rejection sink of a usual payload is at 250-325 K and the minimal continuous duty lifetime is 10 years. Two axis gimbals operate across 0-359 degrees in azimuth and 0-90 degrees in elevation. High heat flux microcircuits of interest are the radiation hardened versions of various Field Programmable Gate Arrays (FPGAs) and variants of the Power PC CPU. Proposals concerned with waste heat rejection from or cooling load transfer to refrigerated cryogenic sensors must describe how the thermodynamic system notionally proposed supports 35 K focal plane cooling needs on the order of 2 W and 85 K optics cooling needs on the order of 15 W, or waste heat rejection on the order of 500 W. Multistage refrigeration is therefore an explicit requirement in these payloads. Showing how the component improvement would benefit currently available designs for space EO payload either as efficiency improvements or as reductions in payload budgets must be discussed in the proposal.

Mass improvements for gimbaled payloads are currently assessed relative to the following payload trade budgets:
- 0.3 kg/W of heat rejection for rejection radiator

- 0.2 kg/W of power input
- 30% of refrigerator mass and radiator for on gimbal cooling

Consequently, moving a 100 W refrigerator of 10 kg mass off gimbal would save 0.3 x[10+ (0.3 x 100)] = 12 kg of payload mass. An alternative to save this same 12 kg mass penalty would be to increase cooling efficiency on gimbal so that the power input would be only 45.5 W. It should be obvious from this analysis approach that controlling size (up to an upper linear dimension limit of 2 meters) or component intrinsic mass is not a primary objective of this topic; instead, payload mass savings in excess of 10 kg are the prime mass objective.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased efficiency or reduced mass, jitter, or power input of space EO payloads or their supported spacecraft. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a space payload simulated in ground testing conditions. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, payload, and/or refrigeration contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications. Demonstration of the potential improvements in efficiency or mass reduction of space cryogenic coolers or space payloads should be included in the effort using commercially-available high-heat-flux parts. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or refrigeration contractors.

PHASE III: Typical MDA military space applications for cryogenic sensing systems relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS). Other potential Phase III opportunities to transfer this technology include the Advanced Infrared Satellite System (AIRSS) and block upgrades to other Ballistic Missile Defense Systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased efficiency and to a lesser extent the expected reduction in mass for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

REFERENCES:
1. T. Roberts and F. Roush, USAF Cryogenic Thermal Management System Needs, Proceedings of the 2007 Cryogenic Engineering Conference

2. Davis, T. M., Reilly, J., and Tomlinson, B. J., USAF "Air Force Research Laboratory Cryocooler Technology Development," Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 21-32.

3. Roberts, T. and Roush, F., Cryogenic Refrigeration Systems as an Enabling Technology in Space Sensing Missions, Proceedings of the International Cryocooler Conference 14, to be published in Cryocoolers 14, 2007.

4. Donabedian, M. and Gilmore, D., Spacecraft Thermal Control Handbook, Plenum Press, NYC, and Aerospace Press, El Segundo, CA, 2003.

5. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.

6. Razani, A. et al, “A Power Efficiency Diagram for Performance Evaluation of Cryocoolers”, Adv. in Cryo. Eng., v. 49B, Amer. Inst. of Physics, Melville, NY; p. 1527-1535, 2004.

KEYWORDS: cryocooler, cryogenic, Infrared Sensors

MDA08-011 TITLE: Space Component Miniaturization

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop and test miniaturized, lightweight, space qualified components to support future MDA missions. Although this is a broad topic area, this year we are placing special emphasis on two technology areas. The first area of emphasis is the development of a space qualifiable, broad bandwidth, near reactionless, fast steering mirror (FSM). The second area of interest is in the development of a lightweight, agile, high efficiency solar aray drive assembly (SADA). Offerors may also propose other highly innovative component miniaturization efforts for consideration under this topic, but discussion with the topic authors is strongly encouraged first!

DESCRIPTION: The Space Tracking and Surveillance System (STSS) requires both extremely high-resolution Line of Sight (LOS) stabilization and inertial pointing knowledge AND high agility to track targets of interest for the Ballistic Missile Defense System.

To achieve these, STSS is very interested in the development of a space qualifiable, broad bandwidth, reactionless, fast steering mirror (FSM) to support future line of sight (LOS) stabilization, pointing, and tracking control system architectures. Unique, innovative approaches are required to allow operations at cryogenic temperatures, reactionless mirror actuation technology to minimize self-generated disturbances and improve overall system performance and new approaches to the development of space qualified electronics, actuators, sensors and control system architectures to meet performance goals and on-orbit life requirements. An integrated design approach demonstrating a path to the development of a fully functional, space qualifiable FSM is desired, but extremely unique approaches to critical subsystem components will also be considered. Specific performance goals for this effort are presented below in Tables 1 & 2.

Another area of interest is in the development of a lightweight, agile, high efficiency solar array drive assembly (SADA). Current SADAs are designed to provide small angular rates and accelerations to optimize the orientation of solar arrays as the satellite slowly orbits the earth. A highly agile spacecraft, which is one of the STSS design options, will, however require SADAs capable of higher rates and accelerations needed to compensate for the rapidly changing spacecraft pointing as well as the change in sun-angle as the spacecraft orbits; in essence, the spacecraft and SADA must work in concert to allow rapid large angle spacecraft maneuvers while maintaining optimal solar incidence angle. Offers must consider control system interactions (between SADA, solar array, spacecraft, and spacecraft control system). High efficiency, agile torque mortors, rate sensors, and control electronics will be required as will control algorithms, for a SADA capable of meeting the design requirements. All designs must be space qualifiable. Such a capability will enable the program to open a larger trade space in the development spacecraft architectures by trading spacecraft agility vs. gimbals (and the impact on mass, power, and pointing stability). Specific performance goals for this effort are presented below in Tables 1 & 3.

In addition, all components proposed in this area must address space qualifiability. The following space environmental parameters listed in Table 1 below should be used as guidance.

Table 1: Space Environmental Parameters

Space Environment Parameters:	Near Term Goal	Far Term Goal
Vacuum operations:	Yes	-
Shelf life - years:	3	5
On-orbit Service Life - years:	10	15
Radiation Hardness (Proton – nominal 63 MeV):	300 kRad	1 MRad
Radiation Hardness (Ionizing):	300 kRad	1 MRad
Operating Temperature Range:	-54 to 32 C	-
Survival Temperature Range:	-60 to 71 C	-

Table 2: Fast Steering Mirror (FSM) Performance Goals

Parameter:	Near Term Goal	Far Term Goal
Nominal Clear Aperture:	5 in	-
Angular Range:	2.5 deg	3.0 deg
Open-Loop Bandwidth over 90% of mechanical stroke:	>1000 Hz	>2000 Hz
Open-Loop Phase Margin over 90% of mechanical mirror deflection:	> 40 deg	>45 deg
Open-Loop Gain Margin over 90% of mechanical mirror deflection:	>9 dB	>12 dB
Error Rejection for freq < 10 Hz:	> 60 dB	> 80 dB
Peak Angular Acceleration:	> 500 rad/s^2	> 1000 rad/s^2
Noise Equivalent Angle (microradian):	< 1.0	< 0.5
Residual Reaction Torque (% commanded torque):	< 0.1	< 0.01
Command Resolution (microradian):	< 1.0	< 0.5
Mechanism volume (inches):	8x8x8	7x7x4
Mechanism Weight - include nominal 2m cable (lbs):	< 8	< 5
Peak Power Consumption (Mechanism + electronics):	<30 W	< 25 W
Operating Temperature Range:	80	120 K

Table 3: Solar Array Drive Assembly (SADA) Performance Goals

Parameter:	Near Term Goal	Far Term Goal
Nominal Solar Array size to be supported:	2 kW	4 kW
Sunpointing error off nominal:	1.5 degrees	1.0 degree
Solar Array slew rates:	1.0 deg/sec	10.0 deg/sec

PHASE I: Develop a preliminary design for the proposed component or system. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the offeror understands the physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware development and test is highly desirable. Proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws and feasibility. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, spacecraft, and/or payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Complete critical design of prototype component or system including all supporting MS&A. Fabricate a prototype or engineering demonstration unit (EDU) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. In addition, environmental testing, especially radiation testing, is highly encouraged in this phase. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, spacecraft, and/or payload contractors.

PHASE III: Work with a commercial company or independently develop a commercial product based on the technology developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Steering mirrors have broad application in the academic, commercial and military markets for stabilization of optical systems. Commercial entities are now building private satellites for planetary imaging for a number scientific and commercial applications. These mirrors can also be used in high altitude, unmanned reconnaissance platforms and other imaging systems. The solar array drive assemblies (SADAs) are of more limited application to large commercial and military satellites. There is additional potential commercial spin off into the robotics industry. However, this topic is open to any innovative, novel miniaturization concept which may have broader commercial appeal as well.

REFERENCES:
1. Sweeney, M; Rynkowski, G; Ketabchi, M; Crowley, R; "Design considerations for fast-steering mirrors (FSMs)," SPIE Proceeding Volume 4773, Optical Scanning 2002, Stephen F. Sagan; Gerald F. Marshall; Leo Beiser, Editors, pp.63-73, 4 Jun 2002.

2. Sweeney, M; Erdelyi, E; Ketabchi, M; Kent, B; "Design considerations for optical pointing and scanning mechanisms", SPIE Proceedings Volume 5176, Optomechanics 2003, Alson E. Hatheway, Editors, pp.135-146, 27 Oct 2003.

3. Xie, M; Ma, J; Fu, C; "Design and experiment of a LQ controller used in high-bandwidth fast-steering mirror system", SPIE Proceedings Volume 4025, Acquisition, Tracking, and Pointing XIV, Michael K. Masten; Larry A. Stockum, Editors, pp.250-258, 7 July 2000.

4. Tapos, F; Edinger, D; Hilby, T; Ni, M; Holmes, B; Stubbs, D; "High bandwidth fast steering mirror", SPIE Proceedings Volume 5877, Optomechanics 2005, Alson E. Hatheway, Editors, 587707, 9 September 2005.

KEYWORDS: Space Components, Spacecraft Components, Fast Steering Mirror, FSM, Solar Array Drive Assembly, SADA

MDA08-012 TITLE: <u>Advanced Space Power Management & Energy Storage Technologies</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop advanced space power management and storage for MDA satellite applications.

DESCRIPTION: The Spacecraft Electrical Power Subsystem (EPS) performs a critical role for on-orbit operations by providing electrical power to spacecraft subsystems and payloads through a combination of several functions that include energy conversion, storage, management, and distribution. In performance of these functions, the EPS typically consumes more than one third of the spacecraft mass budget. In addition, the components of the EPS often determine the expected lifetime of the spacecraft. The goal of this topic is to develop advanced space power technologies that improve overall EPS performance as measured by EPS system overall efficiency, environmental survivability, and manufacturability. Specifically, improvements are sought in technologies that perform the two EPS functions: energy storage and Power Management and Distribution (PMAD). Power system technologies that perform these functions and are of interest are listed below:

Batteries: Three main interest areas for space-based rechargeable batteries include development of alternate, stable sources of precursor materials used in manufacturing space-grade rechargeable batteries, improving low temperature (below -20C) and radiation exposure (300KRad total dose) survivability and performance of lithium-ion space batteries, and improving the mechanical integrity and handling safety of these batteries. For the precursor aspect of this topic, desired innovations should enable the manufacturing of high purity, consistent cell materials suitable for, or currently used in rechargeable space batteries. Examples include anode, cathode and separator materials, as well as electrolyte compositions, for lithium-ion cells, and other materials for nickel hydrogen cells. The second focus area for low temperature operation of space cells encompasses innovations that will allow rechargeable lithium-ion cells to survive short to medium excursions (hours to days) to very cold temperatures without sustaining unacceptable damage or excessive loss of capacity. A third focus area encompasses the survivability of the battery when exposed to intense radiation, which may occur in highly elliptical orbits, and incidentally, in extraplanetary environments. The final emphasis area includes innovations that increase or alter the mechanical integrity of space lithium-ion cells to help prevent safety incidents resulting from mishandling, accidental short circuits and shocks to personnel who are working with these cells. Proposed battery technologies should complement an overall battery system performance goal to achieve performance levels exceeding the current State-of-the-Art (SOA) in terms of specific energy density (W-hr/kg), volumetric energy density (W-hr/l), cycle life, calendar life, and an operational battery lifetime of 10 years in MEO.

PMAD: Development of PMAD system and component concepts for radiation hard (>300 kRad total dose) applications that may also reduce mass, volume, operate at high efficiency, and are reliable and producible is desired. While concepts applicable to moderate voltage (28V) systems are of interest, concepts applicable to higher voltage (75-100V) are of particular interest. Increases in PMAD component efficiency and reliability have a ripple effect that can reduce the quantity of batteries and solar cells required by a space system while reducing thermal control issues. Strategies for reducing PMAD mass and increasing efficiency for the high-voltage space environment may involve increased frequency devices, higher bus voltage technologies, distributed power electronics, and increased radiation hardening of existing components. Reliability of components should support a 10 year mission in LEO/MEO.

A single proposal should seek to address only one of the two EPS technologies listed above in relation to the stated MDA satellite applications, and in sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with their incorporation into DOD systems. Should the proposing firm desire to propose solutions for multiple EPS components, a proposal for each specific concept/technology should be submitted.

PHASE I: Design and develop representative proof of concept hardware for either battery or PMAD technology. This hardware will be tested to characterize performance and to assist in developing a Phase II design strategy. The hardware should be functionally tested in operationally driven modes and analyzed for their path to representative environments. The contractor will identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) a development and integration strategy, potential flight demonstration opportunities, program schedule, and estimated costs. Proposing firms are strongly encouraged to work with MDA satellite payload and system contractors to understand the EPS requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PHASE II: Using the lessons learned from fabricating and testing the prototype in Phase I, design and fabricate a prototype concept that can be integrated into an MDA system. The prototype will be tested in accordance with MDA/SS operational and environmental parameters. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from system and payload contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many other military and commercial applications that can benefit from the enhanced capabilities, as well as mass and cost savings associated with this technology. The first use of these technologies is envisioned for the Space Tracking and Surveillance System (STSS), but planning may envision additional applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The government and commercial potential for increased performance of space EPS components is high. Other government agencies are interested in satellite power systems which are sustainable in extraplanetary environments. Commercial satellite providers are a significant fraction of the space market and are continually looking for ways to reduce system mass, decrease costs, and increase spacecraft reliability and lifetime. Rechargeable batteries are used in commercial aerospace applications for on-board power and innovations developed under this topic are likely to benefit various commercial spacecraft applications.

REFERENCES:
1. http://www.acq.osd.mil/mda/mdalink/html/mdalink.html provides an overview of MDA platforms.

2. http://www.electrochem.org provides detailed information on current state-of-the-art advances and research, mainly for MDA-interest rechargeable batteries.

3. Handbook of Batteries, 3rd Edition, McGraw-Hill, provides detailed information regarding the design and construction of thermal, liquid reserve and rechargeable batteries.

4. http://www.eaglepicher.com/EaglePicherInternet/Technologies/Power_ Group/Defense_Applications, Products Services provides documents describing MDA-interest batteries and related technology.

5. http://www.lithion.com/lithion/index.html provides links to various documents describing MDA-interest rechargeable lithium battery technology.

6. http://www.terma.com/multimedia/Power_M anagement4.pdf provides an overview of power management and distribution systems for space based applications.

7. Kimnach, G. L. and Soltis, J. V., "Power management and distribution trades studies for a deep-space mission scientific spacecraft", AIP Conference Proceedings; 2004; no.699, p.590-7.

8. Prater, A., Simburger, E. J., Smith, D., Carian, P. J., and Matsumoto, J., "Power Management and Distribution Concept for Microsatellites and Nanosatellites", proceedings of IECEC, 1-5 August 1999.

9. Tan, F.D. "Series of Radiation-hardened, High-Efficiency Converters for High Voltage Bus", IEEE Transactions on Aerospace and Electronic Systems, October 2002, v. 38, no 4, p. 1324-1334.

KEYWORDS: Electrical Power, Space Power, Power Generation, Power Storage, Power Management & Distribution, Space Based Battery, Power Density, Energy Density, Lithium-Ion, Rechargeable Battery

MDA08-013 TITLE: Advanced Space Sensor Components and Concepts

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to develop innovative solutions to improve strategic space sensors.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in technology developments in support of advanced space sensor systems. MDA requires high performance, high sensitivity and low noise sensors for space based sensing applications. Space based sensors operate in low background environments where radiation hardness is key to mission operation. Sensor bands from the visible through very long wavelength infrared (IR) wavelengths are of greatest interest; innovative concepts exploiting Radio-Frequency (RF) emissions are also of significant interest. For both visible and infrared sensors, specific technology areas of interest include: detectors; detector materials and processing (both bulk substrates and epitaxial materials); focal plane arrays (FPAs) including Read Out Integrated Circuits (ROIC), design, processing, hybridization techniques and packaging. All proposed efforts must be capable of operation in a space/nuclear radiation environment, provide performance sufficient for strategic systems to meet the requirements of the BMDS; and offer system performance advantages over current sensor capabilities/approaches. Advanced space sensor concepts (Visible, IR, or RF, including passive RF sensing) which improve spatial, spectral and temporal resolution resulting in significantly enhanced sensor accuracy and timeliness are of interest.

Infrared Detector Solutions:
The Missile Defense Agency are interested in new approaches to accomplish near (NIR), mid (MWIR), mid-long (M-LWIR), long (LWIR) and very long (VLWIR) wavelength infrared staring arrays. Enhancements sought include increased operating temperature (e.g, for LWIR, >60K), larger format and improved detectivity for space based applications. Detectors with increased operating temperatures with equivalent or better detectivity than the current state of the art will significantly reduce satellite system costs; improved detectivity itself may also lower satellite system cost by decreasing the number of satellites required for the mission. Key issues to be addressed are detector substrates and substrate processing, innovative detector materials design and device architectures, materials growth and processing (including diode passivation), with additional attention to materials composition and doping control. Material issues are minimizing background carrier concentration and defect densities. Molecular beam epitaxy and metal organic chemical vapor deposition will be considered, as well as other similar epitaxial growth techniques. Efforts decreasing technical risk and improving producibility of large format FPAs (up to 1024 x 1024 pixels, 40 mu m or smaller pitch) are most desired. Proposed solutions must address meeting 300 kRad(Si) total dose (nuclear particle, e.g. protons and ionizing radiation) over the expected mission life.

Read-Out Integrated Circuit (ROIC) Solutions:
MDA is interested in ROIC design solutions that may decrease the circuit complexity, increase the operational lifetime and provide immunity against extraneous events. Innovative rad-hard by design and optically hardened ROIC concepts that can be fabricated by known CMOS foundries are of interest to MDA. Radiation hard by design ROICS decrease the overall cost of FPAs by exploiting existing commercial foundries rather than relying on increasingly scarce and costly “proven” foundries. ROIC designs must be radiation hard to 300kRads(Si) (both ionizing and nuclear particle) total dose and include features for mitigation of single-event upsets and latch-up. New and innovative approaches to optical hardened ROICs are of high interest to reduce the impact of glint on CMOS sub-components. These approaches would involve the exploration of specific circuit designs and/or modification of current designs to intrinsically harden the ROIC from stray light excitation. Proposed solutions may address radiation hardening and optical hardening separately. Again, efforts decreasing technical risk and improving producibility of large format FPAs (up to 1024 x 1024 pixels, 40 mu m or smaller pitch) are most desired.

Focal Plane Array Hybridization and Packaging Solutions:
MDA is interested in innovative hybridization and packaging techniques that would enable larger format infrared focal plane arrays, increase throughput and decrease component costs. Again, efforts decreasing technical risk and improving producibility of large format FPAs (up to 1024 x 1024 pixels, 40 mu m or smaller pitch) are most desired.

Advanced Sensor Concepts Solutions:
MDA is interested in innovative concepts that would enhance their ability to perform the space sensing function required for the BMDS. These concepts could include (but are not limited to): software for high fidelity signal extraction; algorithms for close-spaced object discrimination; sensor calibration techniques or advanced sensor designs such as spectroscopic imagers that may enhance spectral, spatial and/or temporal resolution; or concepts that exploit existing RF emissions. (Please note: Space Based Radar concepts are NOT within the scope of this topic.)

This solicitation is broad based, from architecture changes to components to entire sensor concepts. Specifically sought are new and innovative approaches and technologies that involve modified production processes, improved or new materials, altered chip packaging, unique/modified sensor types or designs or other innovative options that will increase performance of space based sensors. Radiation hardness and the ability for the technology to be qualified for space applications are crucial for successful proposals.

Any proposal submitted must focus on one specific area: the detector, the focal plane, ROIC, or an advanced sensor concept. An offeror may submit multiple proposals with unique approaches in one area, or in interrelated areas.

PHASE I: Identify and investigate materials, unique device designs, novel sensor architectures, and/or production process changes or additions suitable for FPA component fabrication that will result in significant improvement in the performance, operational lifetimes or cost reduction. A deliverable or proof-of-concept design available to the government for additional characterization is highly desirable. Advanced Sensor Concepts would design and conduct laboratory experiments to evaluate potential implementation techniques. Offerors are strongly encouraged to work with system, payload and component contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: Using the resulting materials, designs, architectures, concepts and/or process changes or additions in Phase I, implement, test and verify these changes in prototype fashion to demonstrate the feasibility and efficacy of the focal plane array components. In Phase II, the contractor is required to have radiation testing performed to verify that hardening to nuclear particle damage and ionizing radiation to a total dose of 300 kRads(Si) is established and damage is minimized. A full scale processing methodology shall be developed and demonstrated. Advanced Sensor Concepts would produce a prototype of the designed instrumentation and demonstrate in appropriate test. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from, system, payload and/or component contractors.

PHASE III: Either solely, or in partnership with a suitable production foundry, implement, test and verify in full scale the Phase II demonstration item as an economically viable product. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to BMDS systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Possible uses for these products include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. Enhancements to imaging quality show significant potential.

REFERENCES:
1. Spratt, J.P., B.C. Passenheim, R.E. Leadon, S. Clark, and D.J. Strobel. "Effectiveness of IC Shielded Packages Against Space Radiation", T-NS, pp. 2018-2025, December 1997.

2. J. Janesick, G. Soli, T. Elliott, and S. Collins, "The Effects of Proton Damage on Charge-Coupled Devices," Proc. SPIE, Vol. 1447, pp. 87-108, 1991.

3. H. Angus Macleod, Thin-Film Optical Filters, (Institute of Physics, Bristol, 2001).

4. J. Kerekes and J. Baum, “Hyperspectral Imaging System Modeling“, Lincoln Laboratory Journal, Volume 14 (1), pp.117-130.

5. "Chemical Cleaning of GaSb (1,0,0) Surfaces," L. J. Gomez-Zazo et al., J. Electrochem. Soc. Vol. 136, pg. 1480 (1989).

KEYWORDS: infrared detectors; radio frequency (RF) detectors, infrared focal plane arrays, radiation hardening, advanced sensor concepts

MDA08-014 TITLE: Radiation-Hardened Memory

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop (design, fabricate, test) high performance, radiation hardened monolithic, volatile or non-volatile memory components to support the diverse needs of MDA programs.

DESCRIPTION: Space-based sensor and avionic systems require copious amounts of both static random access memory (SRAM) and non-volatile memory (NVM) to store program instructions and data, and configuration data for reconfigurable field programmable gate arrays (FPGAs). The lack of high speed SRAM can produce bottlenecks in data processing systems thereby negating the benefits of advanced processors. Because the size of radiation hardened SRAM is relatively small (4 Mbit to 16 Mbits), large numbers of packages must be flown with the consequent increase in the size, weight, and power of the electronics subsystems. Similarly, space systems using the largest, state-of-the-art reconfigurable FPGA technology require large amounts (>80 Mbits) of NVM to retain the configuration information. Existing radiation hardened NVM are small (1 Mbit to 4 Mbit), so large numbers of packages must be flown to meet these requirements, also.

Near term (3 to 5 year) estimates of space system memory needs indicate that the size of monolithic SRAM must increase to at least 64 Mbit and monolithic NVM must increase to a minimum of 16 Mbit. Achieving these target sizes will require significant innovation in adapting commercial volatile and non-volatile memory technologies to achieve the bit density, speed, reliability and radiation hardness needed for extended space missions. However, many advanced commercial processes are relatively tolerant to total ionizing dose radiation (i.e., maintain specified leakage currents and performance at >100 Krad(Si)). The use of minor process adjustments and/or the addition of some hardening-by-design techniques could increase the hardness of these processes to 300 Krad(Si) or more. Several commercial non-volatile memory technologies (e.g., FERAM, MRAM, and PRAM) are inherently insensitive to relatively high levels of radiation, but the underlying CMOS circuitry must be hardened.

For both volatile and non-volatile memories, the use of error detection and correction techniques with careful physical layout and the application of self-scrubbing circuits could permit single event error rates to be held below 10-12 errors per bit day. Also, careful design of the power bus and attention to well and substrate contacts could achieve ionizing dose rate upsets of at least 5x108 rad(Si)/s.

PHASE I: After selecting a memory type (e.g., SRAM, MRAM, etc.) and a process technology, perform a design feasibility study to evaluate the capability to design, process, and test an advanced, radiation hardened, monolithic memory. The study should include simulation of proposed architectural, electrical, and physical design using models derived from the selected process technology. The results should indicate expected pre- and post-irradiation performance, power requirements, die dimensions, and anticipated yield. If the analyses indicate that the target specifications cannot be met with viable yields, alternative targets should be recommended. This is a monolithic memory development program; therefore, proposals that focus on employing advanced packaging to provide multiple memory chips within a single package will not be considered.

The target size for the SRAM shall be a minimum of 64 Mbits. Concepts proposed shall have target access time < 10 ns, and total dose radiation hardness >300 Krad(Si). Additional goals are radiation hardness to 5x108 rad(Si)/s for ionizing dose rate, and 10-12 errors per bit day for single event effects. The offeror shall select an interface standard that is appropriate for high data throughput and is of interest to MDA system contractors.

The target size for the NVM shall be a minimum of 16 Mbits. Target retention shall be 10 years with a requirement for endurance to exceed 104 cycles. Target read access time shall be less than 100 ns and write cycle time shall be less than 500 ns. The primary application is expected to be as an EEPROM. However, the offeror should work with MDA system contractors to determine desired organization and interface standards. Target radiation hardness level requirements and goals are the same as the SRAM.

For both concepts, offerors are strongly encouraged to work with system, payload and component contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: The offeror shall complete the design of the SRAM or NVM, fabricate the design, and perform electrical and radiation testing to evaluate the ability of the product to meet the target performance and radiation hardness.

The offeror, working closely with the Government Program Manager, may arrange access to government radiation sources for verification testing. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from, system, payload and/or component contractors.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned to be the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: Memory is a ubiquitous component in all modern electronic systems. The devices developed under this program are expected to find application in commercial space electronics, nuclear reactor electronics, and cyclotron instrumentation systems.

REFERENCES:
1. William D. Brown (Editor), Joe Brewer (Editor) Nonvolatile Semiconductor Memory Technology: A Comprehensive Guide to Understanding and Using NVSM Devices, ISBN: 978-0-7803-1173-2, October 1997, Wiley-IEEE Press.

2. C. Hafer, et al., "SEE and TID Results for a Rad Hard-by-Design 16 Mbit SRAM with Embedded EDAC, 2006 IEEE Radiation Effects Data Workshop Record, p131.

3. D. N. Nguyen and F. Irom, Total Ionizing Dose Tests on Non-Volatile Memories: Flash and MRAM, 2007 IEEE Radiation Effects Data Workshop Record, p 194.

KEYWORDS: Memory, SRAM, Non-volatile memory, radiation hardened, single event effects, total ionizing dose

MDA08-015 TITLE: <u>Real Time Monitoring of Natural and Enhanced Space Environments</u>

TECHNOLOGY AREAS: Battlespace, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop (design, fabricate, and demonstrate) innovative sensors and sensor algorithms to detect, characterize (i.e., provide attribution), report, and mitigate, in near real time, mission critical space environmental events or effects occurring from natural and/or manmade origins that could potentially inhibit performance of the Ballistic Missile Defense System.

DESCRIPTION: Real time sensing of, and accommodation for, manmade anomalies or natural perturbations in the space environment is fundamentally required for assured operation of the Ballistic Missile Defense System across the full threat spectrum. Anomalies can include the effect of abnormal electro-magnetic and particle irradiance that may affect the spacecraft sensors and/or onboard electronics, spacecraft power generation capability or thermal behavior of the space vehicle, space vehicle to ground communication, debris impact (mechanical damage), and/or other effects. Natural effects may also include stressing radiance perturbations on infrared sensors that may impact the ability of a sensor to detect and track small dim targets. Real time sensing may be needed to detect and track objects in the vicinity of the host vehicle, providing the data needed for collision avoidance maneuvers if appropriate. Real time sensing systems of natural phenomena will enable accommodation of effects due to phenomenologies associated with radiance perturbations, especially in viewing the earth-limb. Mitigation and correction of unwanted image anomalies due to limb radiance perturbations is sought. Correction may be but is not limited to modeling or temporal-spatial rejection. This would allow BMDS to see small dim targets that are otherwise obscured by stressing scenes. Data gathered would support autonomous operation may to protect the vehicle from immediate damage or destruction and/or to adaptively correct for earth-limb radiance effects. The ability to easily integrate small environmental monitoring/proximity detection sensors, with the capability to provide accurate attribution of anomalous events, onto an existing vehicle would enable enhanced vehicle autonomy, safety, and improved mission effectiveness. Secondary environmental sensing of the natural environment by the principal optical sensors may also be used as data feeds.

Events/Phenomena of interest include:
-- Anomalous irradiance that may indicate the onset of damage to the spacecraft.
-- Objects within 50 km of the host vehicle have relative velocities up to 300 m/s and angular rates up to 20 deg/s
-- Imagery effects from stochastic and wave-like earthlimb perturbations due to gravity wave propagation. Other imagery effects may occur from several natural phenomenological events, such as aurora and polar mesospheric clouds.

Active and passive detection techniques should be considered, to include optical (visible and IR) as well as radio through millimeter wavelengths. Integration of multiple sensing technologies should also be considered. Exploitation of the principal optical sensors on the space vehicle to perform software mitigation or correction of optical impacts on the principal sensors should also be considered. Any device proposed must be capable of 10 years operation in a space environment, including 300Krad total dose of radiation (ionizing and proton). Furthermore, as power and heat rejection capability are at a premium in spacecraft, minimizing power and thermal management requirements of a proposed instrument are also key design issues. Design goals also include volume < 30 cubic in., weight < 2.5 lb., and power < 20 W.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concept for detection, tracking, reporting, correction, and mitigation approaches. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a space payload simulated in ground testing conditions. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system and/or payload, contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and conduct appropriate analysis and supporting experiments to support development of a working prototype of the proposed solution; this sensor may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications. The performance of this prototype sensor should be characterized under simulated space environment conditions to demonstrate the performance of the concept. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: Concept may be useful for sensing of debris or hazards in the vicinity of geosynchronous satellites, determining whether satellites have successfully separated from launch vehicles. Concept may also be useful for mitigating environmental effects on commercial imaging and communications satellites. There is also potential application to environmental retrieval of mesospheric composition for nowcasting/forecasting potential environmental impacts on sensor performance.

REFERENCES:
1. Autonomous vehicle programs and applications at SPAWAR Systems Center, Fletcher, B.(OCEANS apos; 99 MTS/IEEE. Riding the Crest into the 21st Century, Volume 1, Issue , 1999 Page(s):196 - 200 vol. 1).

2. Integrating self-health awareness in autonomous systems, Karl M. Reichard, The Applied Research Laboratory, The Pennsylvania State University, P.O. Box 30, State College, PA 16804, USA.

3. Satellite Threat Warning and Attach Reporting, D.H. Hilland, G.S. Phipps, C.M. Jingle, and G. Newton, 1998 IEEE.

4. Method and system for detecting and determining successful interception of missiles, United States Patent 6720907.

5. Effective Coverage Control for Mobile Sensor Networks With Guaranteed Collision Avoidance, Islam I. Hussein and Dusan M. Stipanovic, IEEE Transactions on Control Systems Technology, VOL. 15, NO. 4, July 2007.

6. Optimal filtering, Brian D. O. Anderson, John B. Moore, Englewood Cliffs, N.J., Prentice-Hall, c1979.

7. M. Fernandez, A. Aridgides, and D. Bray, "Detecting and tracking low-observable targets using IR," SPIE Proceedings: Signal and Data Processing of Small Targets, (O.E. Drummond, Ed.), Vol. 1305, pp. 193-206, Orlando, 1990.

8. H. Dothe, J.W. Duff, J.H. Gruninger, P.K. Acharya, A. Berk, and J.H. Brown, "USERS' MANUAL FOR SAMM-2, SHARC-4 and MODTRAN-4 MERGED, AFRL-VS-HA-TR-2004-1001.

9. Tartakovski, A., Volson, L., and Brown, J., "Adaptive Spatial-Temporal Filters for Clutter Removal and Scene Stabilization," 2005 Meeting of the Military Sensing Symposia (MSS) Specialty Group on Missile Defense Sensors, Environments and Algorithms (MD-SEA), Monterey, CA 25-27 October 2005.

10. Brent Y. Bartschi, David E. Morse, and Tom L. Woolston, "The Spatial Infrared Imaging Telescope III," Johns Hopkins APL Technical Digest, Volume 17, Number 2 (1996), pp. 215-225.

11. Jefferson Morris, "Raytheon to deliver second STSS payload in July," Aerospace Daily & Defense Report, 05/25/2006, page 20.

12. Jefferson Morris, "USAF Reconsiders Surveillance of Satellites," Aviation Week & Space Technology, 05/15/2006, page 30.

13. Jefferson Morris, "GAO letter cites AF progress in space acquisition," Aerospace Daily & Defense Report, 06/05/2006, page 19.

14. Jefferson Morris, "Air Force completes restructuring of SBSS Pathfinder program," Aerospace Daily & Defense Report, 05/10/2006, page 01.

15. Marcia S. Smith, "Military Space Programs: Issues Concerning DOD's SBIRS and STSS Programs", CRS Report for Congress, Congressional Research Service, The Library of Congress, Order Code RS21148, Updated January 30, 2006.

16. Adler-Golden, S. M., Matthew, M. W., Bernstein, L. S., Levine, R. Y., Berk, A., Richtsmeier, S. C., Acharya, P. K., Anderson, G. P., Felde, G., Gardner, J., Hike, M., Jeong, L. S., Pukall, B., Mello, J., Ratkowski, A., and Burke, H. -H. 1999. Atmospheric correction for short-wave spectral imagery based on MODTRAN4. SPIE Proc. Imaging Spectrometry, 3753:61-69.

17. Matthew, M. W., Adler-Golden, S. M., Berk, A., Richtsmeier, S. C., Levin, R. Y., Bernstein, L. S., Acharya, P. K., Anderson, G. P., Felde, G. W., Hoke, M. P., Ratkowski, A., Burke, H.-H., Kaiser, R. D., and Miller, D. P. 2000. Status of atmospheric correction using a MODTRAN4-based algorithm. SPIE Proc. Algorithms for Multispectral, Hyperspectral, and Ultraspectral Imagery VI, 4049:199-207.

WEB SITES:
1. http://www.losangeles.af.mil/SMC/is/sbirs.htm
2. http://www.ll.mit.edu/ST/space-based/home.html
3. http://www.raytheon.com/products/stellent/groups/public/documents/legacy_site/cms01_035231.pdf
4. http://www.creaso.com/english/12_swvis/22_flaash/main.htm

5. http://www.ittvis.com/envi/flaash.asp

KEYWORDS: space environment, threat protection, natural environment, atmospheric correction, limb radiance

MDA08-016 TITLE: Spacecraft Assembly, Integration and Test Enhancement

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Significantly improve the Assembly, Integration, and Test (AI&T) of future MDA Space Borne Electro-Optic (EO) sensor payloads.

DESCRIPTION: Electro-Optic sensor programs typically spend a significant amount of resources testing mission hardware and software. This process can be laborious; require custom STE (Special Test Equipment) that is redesigned at each level of integration to accommodate higher level test requirements, and flight software is validated through a long and arduous process. The Missile Defense Agency seeks to advance the state of the art in the Assembly, Integration and test of Electro-Optic sensors to reduce the cost and time associated with these payloads. The focus of this topic is on space-based sensor systems, however proposals that also support other MDA systems (e.g. ABL) will be considered favorably. Special areas of interest in this topic are: calibration sources, target simulators, and hardware in the loop simulation. Offerors may also propose other highly innovative space vehicle AI&T enhancements for consideration under this topic, but discussion with the topic authors is strongly encouraged first!

The first area of emphasis seeks proposals for optical calibration sources appropriate for use during ground and/or on-orbit test / verification. These systems may be separate from the spacecraft including micro-sat, ground based or sounding rocket launched targets, or internal calibration sources on board the spacecraft. Any proposed system must have a well characterized optical cross section and irradiance.

The second area of emphasis seeks proposals for target simulators for use during ground test and verification. Proposals in this area should address either far field line of sight accuracy and stability, or the development of high fidelity visible / infrared target sources. Line of sight to the micro radian level is required. The target sources should radiate in the visible through Long Wavebands. Knowledge of and the ability to control the irradiance of these sources is critical.

The third area of emphasis seeks proposals for hardware in the loop simulators for use during ground test and verification. The following characteristics are desired. The payload simulator should support simulation-based testing at the various stages of payload development including design, embedded software development, prototype integration, full system integration testing, and training. The payload integration and testing architecture should support pure simulation, software-in-the-loop simulation, man-in-the-loop simulation, and hardware-in-the-loop simulation allowing for maximum reuse of payload simulation and testing assets in all modes of operation. To facilitate a scalable and efficient integration testing process, the system should enable simulation-based test projects to be executed in non-real-time on a general purpose operating system (GPOS) based platform for low-cost test development, verification and validation; and in real-time on a real-time operating system (RTOS) based compute platform for hardware-in-the-loop and man-in-the-loop testing. To assist with obsolescence avoidance, the payload simulator architecture should leverage an open-source RTOS, where possible.

PHASE I: Develop conceptual designs of the hardware based on preliminary analysis. Perform sufficient design and analysis to demonstrate concept feasiblity. Limited testing of critical components or concepts as appropriate is desired. Phase I must produce sufficient data to support development of a clear technology development plan, schedule, budget, requirements documentation, and CONOPs for the development of the Phase II product. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Develop a prototype of the design developed in Phase I. Tasks shall include, but are not limited to, a detailed demonstration of key technical parameters that can be accomplished and a detailed performance analysis of the technology. Ground demonstration of the key capabilities of the design is highly desired. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should develop working relationships with, and support from system and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DOD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The successful development and demonstration of this technology is expected to result in continued use by MDA, other DOD organizations, NASA, and commercial spacecraft developers.

REFERENCES:
1. MDA Link Fact Sheet: Space Tracking and Surveillance System, http://www.mda.mil/mdalink/pdf/stss06.pdf

2. MDA Link Fact Sheet: Airborne Laser, http://www.mda.mil/mdalink/pdf/laser.pdf

3. Public Law 106-65, Oct 5, 1999, Congressional Direction, Appendix G, Space Technology Applications, Space Test Program.

4. J. Nalepka, T. Dube, G. Williams and A. Snyder, Air Force Research Laboratory, Wright-Patterson AFB, OH. “Transitioning to PC-Based Simulation – One Perspective”. AIAA Modeling and Simulation Technology Conference, Monterey, California 2002.

5. R.M. Howe, “An experimental method for estimating dynamic errors in real-time simulation”. AIAA Modeling and Simulation Technology Conference, Denver, CO, Aug. 14-17, 2000.

6. Paul C. Sugden, Melissa A. Rau, Systems Development Branch, NASA Langley Research Center. "Platform-Independence and Scheduling in a Multi-Thread Real-Time Simulation”, AIAA Modeling and Simulation Technology Conference and Exhibit, Montreal Canada, 2001.

7. Python Foundation, Python Open Source Community, http://www.python.org/

KEYWORDS: low cost target, electro optical, sensor, calibration, characterization, optical signature, payload, hardware in the loop, integration, and test

MDA08-017 TITLE: <u>Silicon Carbide (SiC) Cryogenic Optics Technology Advancement</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate technologies for silicon-carbide (SiC) optical systems to be operated in a cryogenic space environment.

DESCRIPTION: Polycrystalline SiC-based materials are being considered as structural substrates for the next generation of lightweight mirrors in aerospace applications because of their low density and coefficient of thermal expansion (CTE) as well as their high strength, stiffness, and fracture toughness. These materials can potentially serve as a single wideband optical structural material to replace both Be and glass optics over the broad thermal span from cryogenic to high temperature levels. The development of silicon carbide to date has made much progress yet does not adequately address surface preparation. Needed surface-preparation technology includes both figuring and finishing technologies capable of producing steep (low focal ratio or “F number”) off-axis mirrors and coating technologies for producing a nuclear-event-hard infrared (IR) coating on SiC. Each proposal submitted will focus on one and only one of the technology areas of this topic (given in no order):

(i) Figuring and Finishing -- New methods are being sought that can figure and finish a SiC mirror without the introduction of damage; examples of damage are surface and sub-surface defects and internal stresses. “Figure” and “finish” are used in the classic optical context of establishing mirror shape at large and small length scales, respectively. The technology needs to be applicable to off-axis parabolas with F numbers below 0.5 and both large and small diameters. The process should minimize cost and schedule and be relevant to the highly lightweight substrate geometry. Feasibility of the technology should initially be demonstrated on 3 inch diameter or larger SiC samples. The offeror should demonstrate the absence of defect and internal trapped stress using the Twyman methodology.

(ii) Coatings -- New methods are sought to develop and demonstrate advanced materials and coating technologies to increase the technology readiness level of an IR mirror system for advanced space assets. The components in this effort should be sized to eventually support 0.5m-class gimbaled optical systems in a cryogenic space environment. The most demanding requirements of IR-reflective coatings on SiC optics is to withstand cryogenic cycling (down to 70-130 K) and the space environment. The space environment includes 300krad total dose (ionizing and proton) of radiation, ultraviolet-radiation exposure, atomic oxygen, and the transmission of high-energy rays (X and gamma) from a nuclear event without causing degradation and spallation of the coating system. The offerors should present a clear, detailed description of their materials as well as how their deposition processes will result in a stress-free, highly adherent IR coating system that meets the demands of a space-qualifiable, cryogenically cooled, radiation-hardened, IR-reflective coating. The offeror will initially perform coating deposition trials on SiC samples at least two inches in diameter. Relevant coating tests may include adhesion to the substrate, cryogenic exposure and thermal cycling, residual stress measurements, environmental durability, and optical performance.

(iii) Integration -- Much of the SiC work done to date has dealt with individual technologies for fabricating or figuring individual SiC mirrors or support structures. Considerably less effort has been devoted to building up a SiC optical system and demonstrating its performance in a simulated operational environment, a process necessary to raise the technology readiness level of SiC optics sufficiently to provide acceptable risk for its application to operational satellites. Under this area, the offeror will design an experimental prototype SiC optical system, fabricate the components, integrate them, and conduct experiments to validate the design methodologies and verify performance predictions both at ambient and simulated operational conditions.

A teaming relationship that includes a SiC vendor and a integrating (or prime) contractor is strongly encouraged both for consistency with the most relevant SiC supply and for a high potential for technology transition. A primary goal shall be to demonstrate the proposed technology on a representative SiC mirror system.

PHASE I: Develop a surface-preparation concept for SiC mirror systems and evaluate initial feasibility at the coupon scale OR design an experimental prototype SiC optical system and analytically predict it’s performance. Offerors are most strongly encouraged to work with system, payload, and/or optical system contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Design, develop, and build a prototype system that includes a lightweighted SiC mirror to demonstrate the innovation to verify performance and limitations. The demonstration should validate applicability of the concept/technology so as to transition the technology to an operational system by subscale demonstration, performance in a relevant environment, or similar incremental approach. Demonstrate the potential of the prototype device to meet actual operational specifications and clearly identify the path to be followed to take the device to a flight-ready status. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with and support from system, payload, and/or optical system contractors.

PHASE III: Develop and implement specific optical coatings technology for use in IR imaging systems such as SBIRS High, SBSS, STSS, or Exoatmospheric Kill Vehicle, with the first application envisioned as the STSS.

PRIVATE SECTOR COMMERCIAL POTENTIAL: SiC is being widely used in the micro-electronics and photonic industry, where SiC often requires precision surfacing and adherent coatings. The availability of surface-preparation and evaluation technologies will improve process design and should significantly increase the likelihood of first-pass success. The innovation requested in the topic will result in cost savings in the modernization of optical systems. Such an innovation has direct application to many branches of the federal government as well as other industries that increasingly utilize optical sensors for critical functions

REFERENCES:
1. Developments in Optical Component Coatings, Proceedings of the SPIE, Volume 2776, Ed. By Ian Reid, Aug 1996.

2. J. A. Randi, J. C. Lambropoulos and S. D. Jacobs, “Subsurface damage in some single crystalline materials,” Applied Optics, 20 April 2005, Vol. 44, No. 12.

3. Optical Materials and Structures Technologies III, Proceedings of SPIE, Volume 6666, Ed. By William A. Goodman and Joseph L. Robichaud, Sep 2007.

KEYWORDS: optical coatings, cryogenic coatings, mirrors, silicon carbide, optical figuring, optical finishing, precision surface ceramics, optical integration

MDA08-018 TITLE: Manufacturing Process Maturation for Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP

OBJECTIVE: The Manufacturing and Producibility (DEP) Directorate of the Missile Defense Agency (MDA) is seeking producibility and cost reduction improvements for low-cost, high-performance materials and components. Reliable performance in both lower and upper boost phases, as well as end game, requires innovative, mature, and reduced-cost manufacturing processes. Applications of interest include solid boost motors as well as solid and liquid propellant divert and attitude control systems (DACS).

DESCRIPTION: MDA propulsion systems exhibit stringent performance requirements while simultaneously exposing materials to severe operating conditions. Erosion-resistant ceramics cannot resist the structural loads imposed by very large temperature gradients. Most ceramics composites exhibit porosity which degrades performance and increases design complexity. Existing insulation materials, such as ethylene propylene diene monomer (EPDM) rubber, exhibit excessive charring which produces particles and gas species that contaminate the exhaust plume and compromise divert valve performance. Ceramic composite materials and high temperature metals that have acceptable performance often employ extremely costly fabrication techniques. High performance propulsion materials often utilize manufacturing processes which are not sufficiently mature, resulting in unacceptable property variability. MDA is seeking:

High temperature, ablation-resistant structural materials: Ablation-resistant materials such as ceramics, composites, and refractory metals for components such as liners, nozzles, and hot gas paths. DACS materials including Zr- or Hf-based materials shall be subjected to pressure up to 3000 psi and flame temperatures from 4000oF to 5000oF. SiC-based composites may be considered, but are known to be temperature limited relative to these goals. Aluminized motor materials (TaC-based) must operate at 2000 psi and at flame temperatures greater than 6000oF. The materials must be able to tolerate large temperature gradients such as those experienced at motor initiation. A typical minimum property is a tensile strength of over 50ksi (345 MPa).

Structural insulation materials: DACS components are attached to missile structures and electronic components that cannot tolerate high temperatures. Currently, most non-pyrolyzing insulation materials have poor mechanical properties. Optimal structural insulation materials will be dimensionally stable to high temperatures, will not pyrolize, and will exhibit nominal 15 ksi (34.5 MPa) strength. Structural insulators will have high fracture toughness and thermal stress resistance, and exhibit low thermal diffusivity. Materials are desired for use at 3000oF with a future temperature goal exceeding 4000oF.

Non-Structural insulation materials: New materials are desired which pyrolyze to form dense, adherent, and low thermal diffusivity char layers. Such materials are typically rubbers (such as EPDM) which are compatible with both case materials and propellant compositions. High elongations (goal: >50%) are desired to enable case-propellant structural compatibility; chemical compatibility must also be considered.

Actuator technology: Low voltage, high power density, high performance actuators for 5 to 2000 lbf applications. Response times should range from 5 ms at 5 lbf to 15 ms above 1000 lbf. Actuation technologies should maintain response, stiffness, and precision performance characteristics at high temperature (>500oF functional capability). Additionally, MDA desires actuation technologies with reduced part counts and designs that enhance reliability and simplicity of fabrication.

Rayon-based ablatives: Manufacturing processes for rayon or rayon-like fiber that can be processed like current rayon precursor fiber for ablative phenolic composite materials used in solid rocket motor nozzles. Candidate processes should produce cellulose-based fiber and be tolerant to current carbonization methods.

PHASE I: Develop a strategy to demonstrate the producibility of the proposed propulsion product including integration with an MDA system. The goal of the Phase I effort will be to demonstrate that it is feasible to increase performance, reduce cost, and/or increase production reliability of the selected component. The proposal should provide a quantifiable assessment of the feasibility and pay-off of the selected technology. Critical experiments and/or analyses to support the Phase I feasibility is desired.

PHASE II: Implement the manufacturing plan and quantify key milestones. Validate the feasibility of the material or component by demonstrating its use in the operation of manufactured items for MDA systems, subsystems, or components (such demonstration assumes adequate material and component characterization). A partnership with a potential supplier of MDA systems, subsystems, or components is highly desirable. Identify commercial applications of the technology and other DoD opportunities that benefit from the innovations.

PHASE III: Complete technology transition via successful demonstration of a new product technology. This demonstration should show near-term application to one or more MDA element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance, and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Manufacturing improvements in materials have direct applicability to space launch vehicles, gas turbines, and automotive technologies. Actuator technologies have wide applicability to the aerospace industry to include both aircraft and rocket technologies. Because of the wide variety of chemicals and materials involved, it is anticipated that the private sector will benefit from test procedures for aging propellants.

REFERENCES:

1. George T. Sutton, "Rocket Propulsion Elements; Introduction to the Engineering of Rockets" Seventh Edition, John Willey and Sons, 2001.

2. Missile Defense Agency Link: http://www.acq.osd.mil/mda/mdalink/html/mdalink.html

3. Ballistic Missile Defense Basics: http://www.acq.osd.mil/mda/mdalink/html/basics.html

KEYWORDS: Composites, Ceramics, Divert and Attitude Control System, High Temperature Material, Insulation, Propellants, Rocket Motor

MDA08-019 TITLE: Improved Performance, More Producible Long Wave IR Integrated Dewar Assemblies

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: DEP

OBJECTIVE: Demonstrate the use of new materials and processes, to improve mission assurance, while reducing cost and schedule for more radiation tolerance and efficient Long Wave IR (8-12 micron) transmission via more producible integrated dewar assembly designs.

DESCRIPTION: Current radiation tolerant, low loss optical windows, specifically Ge windows, have a high absorption coefficient resulting in ~50% transmission loss which is little improved with anti-reflection coatings. Alternative optical window materials such as Diamond, ZnSe, High Density Polyethylene, et al. are available but require new Integrated Dewar Assembly (IDA) design concepts to leverage material performance while mitigating costs and schedule impacts. For example, diamond windows offer a potential of nearly 100% transmission for long wave IR but with less than single crystal optical quality.

For this effort other materials and alternative fabrication processes shall be evaluated to identify lower cost materials and processes, and reductions in the fabrication schedules compared to the present materials and processes. IDA designs involving conventional materials for IR transmission, cold and emissivity shielding, could be investigated. The optical quality of polycrystalline diamond or other alternative long wave IR window materials of a nominal size of 1-2” diameter and ~1mm thick and associated mounting/attachment materials could be assessed. New materials and processes to mount and/or attach windows for IDA cold shield and/or bandpass filters applications which survive missile interceptor kill vehicle (KV) radiation and vibration/shock environments could be evaluated.

PHASE I: The contractor shall evaluate alternative materials, manufacturing processes to include anti-reflective coatings and mount/attachment technologies to enable improved (as compared to Ge) Long Wave IR transmission of suitable diameter (1-2") and thickness (~ 1 mm) which survive both radiation and vibration/shock environments. The intent is to assess alternative materials and processes technologies for future more producible long wave IR IDA designs and to characterize their potential as compared to current long wave IR IDAs. The contractor shall develop a notional design for an improved long wave IR IDA operating in a KV sensor.

PHASE II: In Phase II the contractor shall develop, fabricate, and demonstrate the long wave IR IDA in a laboratory environment. The proposed development and demonstration should be limited to what can be demonstrated in a Phase II program and should demonstrate the technologies necessary to transition the technology. A partnership with a current or potential supplier of MDA KV systems, subsystems or components is highly desirable. Producibility innovations enabling the design of the long wave IR IDA should also be demonstrated. The contractor shall evaluate the commercial benefits and target applications of this technology.

PHASE III: The contractor shall develop a design for a long wave IR IDA related to the transition of this technology to an MDA KV sensor system. The contractor shall implement the design and accomplish an evaluation of the implementation. The design and implementation of this technology is best accomplished through a partnership with an MDA prime contractor.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient IR optical window and associated IDA technology can be used to accomplish long range detection, the exchange of information for automotive, and various security application areas with minimal effort for installation and can be readily moved or removed. A simple design for a missile interceptor KV should result in a low cost solution, and make the overall purchase and installation affordable. The proposal shall provide specific applications with a notional plan of how this technology can be inserted.

REFERENCES:
1. “Advanced Cryogenic Technology for Space Based Infrared Surveillance and Stored Cryogens.” Tomlinson, B.J., Jr.; Aerospace Conference, 2001, IEEE Proceedings, Volume 5, 10-17 March 2007, vol 5, Page(s): 2121-2136.

2. “Development of a Compact Dual-Frequency SIS Receiver,” Shengcai Shi, Inatani, J.; Noguchi, T.; Zhicai Xu;, Millimeter Wave and Far infrared Science and Technology, 1996 Proceedings. 4th International Conference, 12-15 aug. 1996, p 137-140.

3. “Development of a Range of Small Mechanical Cryocoolers for Space and Avionic Applications,”Hocking, Barry; Proc. SPIE 1320, 126, 1990, 13 pages.

4. The SPIRIT thermal system,” M. DiPirro, C. Cottingham, R. Boyle, S. Ollendorf, and D. Leisawitz , Proc. SPIE 6687, 66870D, 2007, 11 pages.

5. Space cryogenic system for SPICA mission, Hiroyuki Sugita, Hiroki Nagai, Takao Nakagawa, Hiroshi Murakami, Toshio Matsumoto, Masahide Murakami, Katsuhiro Narasaki, and Masayuki Hirabayashi, Proc. SPIE 5487, 1625 (2004).

6. “Performance of Short Wave Cutoff MBE HgCdTe 2-D Arrays; SpaceBorne Application for Sensing OH Airglow Wave Structure,” Kumer, John B.; Rairdena, Rick; Swenson, Gary R.; Rowland, Neil; Gault, William;Ward, William, Sensors and Camera Systems for Scientific, Industrial, and Digital Photography Applications II,Morley M. Blouke, John Canosa, Nitin Sampat, Editors, Proceedings of SPIE Vol. 4306 2001, p 31-40.

KEYWORDS: Germanium, diamond, ZnSe, High Density Polyethylene, integrated dewar assembly

MDA08-020 TITLE: Advanced Missile Materials and Process Technologies

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: TH, DEP, GM, AL, KI, AB, KV, PAC-3

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Enhance the performance and/or producibility of missile body structures, components and thermal protection systems for implementation into Ballistic Missile Defense (BMD) systems through development or utilization of novel materials and processes. Provide materials solutions to reduce procurement cost, lower life cycle cost, lower operational maintenance, reduce lead time, enhance mission reliability and improve manufacturability for low-rate, non-labor intensive production for BMD systems.

DESCRIPTION: MDA is seeking high-performance materials and process technologies for enhancement of current and block upgraded missile defense systems. These endo-atmospheric and exo-atmospheric intercept systems are highly complex missile systems. Novel materials and process technologies offer a significant potential for enhancing performance properties while improving producibility of these structures. Process technologies should be appropriate for modest production volumes; incorporate modularity, flexibility, simplified and/or low-cost tooling; and be consistent with Lean and Six Sigma methodologies. The focus of this topic is for the missile body and kill vehicle structures or components, excluding electro-optics and propulsion systems.

Technical areas of interest include, but are not limited to:

Kill Vehicles: The development of components that optimize composite performance to achieve material properties approximating or exceeding those of beryllium while maintaining or enhancing producibility, reliability, cost effectiveness, and volume/mass efficiency. Advanced hybrid composites could serve as replacements for beryllium components if their properties are optimized. In addition, such composites could be tailored for various other missile component applications including high thermal conductivity electronic packaging, electromagnetic interference shielding materials, and coatings or components to improve radiation hardening. The potentially superior properties of these composite components may also lead to improves nuclear survivability and functioning after prolonged periods in battlefield/storage environments by reducing shock, vibration, and thermal stress. Such composites should also provide improved heat dissipation (target > 1000 W/MK) an electromagnetic interference shielding for missile (Exo-atmospheric Kill Vehicle, Multiple ill Vehicle, and Kinetic Energy Interceptor) electronics.

Aerostructures: Advanced missile defense interceptors require lightweight thermal protection systems (TPS) and aerostructures designed to minimize internal temperature rise and ensure missile airframe structural integrity during flight, including operation in adverse weather. These systems must meet a variety of requirements such as weight, erosion/ablation performance, cost, non-ionizing chemistry, and component survivability. New advanced interceptors are expected to achieve much higher velocities and longer flight times resulting in more severe aerothermal heating and loads than current systems. Aeroheating environments vary throughout the structure, but cold wall heating rates of 50-400 Btu/ft2-s and shear rates of 10-50 psf can be used for preliminary material suitability analysis. Weather resistance requirements include impact due to rain, ice, snow, and/or sand, with typical rain rates of 0.5-3.0 inches per hour. Proposals are sought that develop lightweight integrated heat shield and airframe designs which enhance the current TPS designs and improve insulative performance of the TPS, lightning strike performance and rain erosion performance.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle and to improve producibility, increase performance, improve thermal protection, lower cost, or increase reliability. Explore the concept and develop novel material or process for fabrication of a selected missile component. Produce test coupons of the material and measure relevant properties. Assess the fabrication cost and impacts on service methods, safety, reliability, and efficiency. Perform a preliminary manufacturability analysis and cost benefit analysis of deployment showing that the structure can be produced in reasonable quantities and at reasonable cost/yields, based on quantifiable benefits, by employing techniques suitable for scale up.

PHASE II: Based on the results and findings of Phase I, demonstrate the technology by fabricating and testing a prototype on a representative missile structure. Demonstrate feasibility and engineering scale up of proposed technology; identify and address technological hurdles. Demonstrate the system’s viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Demonstrate scalable manufacturing technology during production of the articles. Identify and assess commercial applications of the material or process technology.

PHASE III: Demonstrate new open/modular, non-proprietary composite materials and/or structures technology. provide a potentially qualifiable design for an innovative structure that will provide for advancement of the state-of-the-art in aerospace and missile structure performance, safety, life extension, preventative and other maintenance. Demonstrate commercial scalability of the manufacturing process and the implementation of the software-based design tools for the commercial development and deployment of advanced structures. Commercialize the technology for both military and civilian applications. Demonstration should be in a real system or operational in a system level test-bed.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology should benefit commercial and defense manufacturing through cost reduction, improved reliability, or enhanced producibility and performance.

REFERENCES:
1. Deason, D.M. Missile Defense Materials & Manufacturing Technology Program, ASM Annual Meeting, Columbus, OH, Oct. 2003.

2. Deason, D.M. and Hilmaas, G., et al. "Silicon Carbide Ceramics for Aerospace Applications - Processing, Microstructure, and Property Assessments," Proceedings: Materials Science & Technology Conference, Pittsburg, PA, Oct. 2005.

3. Reynolds, R.A., Nourse, R.N. and Russell, G.W. "Aerothermal Ablation Behavior of Selected Candidate External Insulation Materials," 28th AIAA Joint Propulsion Conference and Exhibit, Jul 1992.

4. Murray, A., Russell, G.W. "Coupled Aeroheating/Ablation Analysis for Missile Configurations," Journal of Spacecraft and Rockets, Vol. 39, No. 4, Apr. 2002.

5. Russell, G.W. "Kinetic Decomposition and Thermal Modeling of Chartek 59C," 29th AIAA Joint Propulsion Conference and Exhibit, Jun 1993.

6. Russell, G.W. "DoD High Speed Aerothermal Analysis and Design - Historical Review and New State of the Art Approaches," NASA Thermal and Fluids Analysis Workshop, NASA Langley Research Center, Hampton, VA, Aug. 2003.

7. Lindsay, J. and O'Hanlon, M.E. Defending America: The Case for Limited National Missile Defense, Brookings Institute Press, Apr. 2001.

KEYWORDS: Missiles, Thermal Control, Thermal Insulation, Lightweight, Shock Resistance, Vibration Resistance, Rain Erosion, Hybrid Composite, Beryllium Replacement, Lightning Strike, Advanced Materials, Reliability, Producibility, Manufacturibility

MDA08-021 TITLE: A Risk Reduction Process for Enhanced Mission Assurance

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP, TH, GM, KI, KV, TC, AB, SS, QS

OBJECTIVE: Component reliability is a key element of Mission Assurance. MDA weapons systems must perform at levels of reliability an order of magnitude higher than their conventional counterparts due to the narrow engagement windows and the requirement for unprecedented accuracy. Ensuring that these systems are capable of meeting these high standards for reliability will require a uniquely proactive and continuous approach to identifying potential reliability and material issues as well as a uniquely focused effort to continuously survey and assess advanced materials and manufacturing practices.

DESCRIPTION: Mission assurance across all MDA weapon systems is continually being impacted by material and component reliability issues. To combat these reliability issues, MDA needs an innovative process to continuously identify, assess, monitor, extrapolate, and forecast technological advances in material and component technologies in 5, 10, and 20 year increments. Continuous and self-learning assessments of future technologies will enhance MDA's ability to effectively align technological advances for MDA to implement promising manufacturing technologies, meet long-term needs, increase reliability, and reduce costs across all weapons systems. The goal is to enhance reliability of parts and materials used in missile defense products by continuously guiding technology development roadmaps to produce self-learning solutions that show promise of reliability improvement at acceptable levels of risk and cost.

Improved reliability and vulnerability assessments: Advanced and innovative methods to capture relevant reliability information from multiple parts utilization and failure history sources is needed to feed an integrated system of filters and algorithms that produce indicators of precedence based on typical reliability measures. Indicators exceeding a precedence threshold will be checked for the extent of MDA exposure. The extent (depth and breadth) of distribution of the reliability problem within MDA concerns should be based on correlation with configuration documents associated with applicable MDA systems. Further, a vulnerability measure is required to determine the parts and materials criticality assignments. The product of a reliability and vulnerability assessment function is need to prioritize, time specific list of reliability issues list that serves as the basis for identification of leading manufacturing and materials solutions.

Monitoring, extrapolation and modeling of future solution scenarios: A monitoring, extrapolation and modeling of future solution scenarios function is required to identify future states of emerging manufacturing and materials processes that have applicability with MDA's prioritized, time specified list of reliability issues. This function should employ leading edge search and assessment methods to continuously identify technology candidates and assess for benefit. The leading edge search and assessment capability must provide a means to capture both qualitative and quantitative information and be capable of translating linguistic values to accommodate variation in richness in data sources. Outputs from the assessment algorithms must indicate a degree of association, degree of reliability benefit, and state of maturity for manufacturing and materials processes and feed a multi-attribute decision framework supporting assessment and visualization.

The resulting extrapolation needs to present a forecast of material and component technologies aligned with MDA needs in a time referenced framework that provides visibility into reliability issues at 5, 10, and 20 year forecast points. At each "time slice", the reporting function should present a mapped set of "discovered" solutions. Mapping must relate issues to solutions and must provide key indicators of confidence in the solution via indexes generated in the assessment function. Key measures of anticipated degree of benefit, indications of cost, and level of maturity should be displayed to assist decision makers charged with monitoring and incorporating manufacturing and materials technology advancements. This application needs to include a scenario forecasting function that allows decision makers to select and "wargame" specific advances into technology roadmaps and assign degrees of confidence to each. The scenario forecasting function must provide a compare and contrast view referenced to the outputs from the reliability and vulnerability assessment. Comparison of "with" and "without" futures should enable decision makers to see the impact of certain investment trajectories.

PHASE I: Development of prototype a framework for the reliability and vulnerability assessment feeding a monitoring, extrapolation, and monitoring of future scenarios function to generate a working representation of the capability of each major function group using breadboard level system capable of emulating a nominal set of inputs/outputs. Where possible, the breadboard system should be limited to scale demonstrations to assist in the judging of merit of the new technology.

PHASE II: Produce the reliability and vulnerability assessment and the monitoring and extrapolation of future scenarios functionality by demonstrating its use in a defined MDA element system, subsystem, and component. Demonstrate a self-learning web-hosted application of both near and long term scenarios to one or more MDA-interest systems. A partnership with a current supplier of an MDA element system, subsystem, and component is highly desirable. The possibility of commercial benefit or application opportunities for the innovation is desirable.

PHASE III: The intention is to successfully implement a reliability and vulnerability assessment driving a monitoring, extrapolation, and modeling of future scenarios for use by MDA and other customers as appropriate. Implementation would include the development of an interactive and self-learning technology roadmap across multiple MDA systems leading to implementation of technological advances in material and component technologies.

PRIVATE SECTOR COMMERCIAL POTENTIAL: A successful reliability and vulnerability assessment driving a monitoring, extrapolation, and monitoring of future scenarios application should be of interest in the commercial sector. Current commercial technology road mapping tools lack a self-learning capability because they are designed to work within much shorter manufacturing and materials technology refresh cycles in which the candidate technologies are more mature and closer to implementation. Commercial entities have a desire to align their future product plans, research and development funds, and manufacturing capacities with future material and component technologies resulting in increased market share and stock value.

REFERENCES:

1. Kapil Aggarwal, “Development of Efficient & Optimized Algorithm for Knowledge Discovery in Spatial Database Systems”, http://www.fig.net/pub/fig2006/papers/ts04/ts04_04_aggarwal_0211.pdf, accessed March 2008.

2. Vineet Gupta, Radha Jagadeesan , and Prakash Panangaden, “Approximate Reasoning for Real-Time Probabilistic Processes”, http://fpl.cs.depaul.edu/rjagadeesan/ftp/QEST04.pdf, accessed March 2008.

3. Saroj and K.K. Bharadwaj, “A Parallel Genetic Algorithm Approach for Automated Discovery of Censored Production Rules”, http://www.actapress.com/Abstract.aspx?paperId=29491, accessed March 2008.

4. A. Porter, A Roper, T. Mason, F. Rossini, and J. Banks, “Forecasting and management of Technology”, Wiley Series in Engineering & Technology Management, 1991.

5. Online definitions of Data Mining and Knowledge Discovery:
a. Knowledge Discovery in Databases (KDD) is the process of extracting interesting, non-trivial, implicit, previously unknown and potentially useful information or patterns from data in large databases.
b. Data Mining is the most important step in the KDD process and involves the application of data analysis and discovery algorithms that, under acceptable computational efficiency limitations, produce a particular enumeration of patterns over the data.
Published by The Intelligent Systems and Software Engineering Labgroup, Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, 2006.

KEYWORDS: Manufacturing processes, materials processes, forecasting, data mining, knowledge discovery, parallel genetic algorithm, censored production rules, variable precision logic, data neighborhood graphs, data neighborhood indexes, multi-attribu

MDA08-022 TITLE: <u>Ballistic Missile Defense System Innovative Power</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP, TH, GM, KI, KV, TC, AB, SS, QS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: MDA is seeking to improve the quality, reliability and producibility of batteries and related power sources through innovative ideas applied in creative ways to accommodate unique MDA system, subsystem and component requirements. These include developing new technologies, improving existing technologies, new applications of existing technologies, and inventive uses of commercial off-the-shelf and military off-the shelf technologies. Please note that some technology encompassed by this topic may be restricted under the International Traffic in Arms Regulations (ITAR, CFR 22, Part 121), which controls the export and import of defense-related material and services. If applicable, offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish.

DESCRIPTION: Many battery and power source products made for missile defense applications are manufactured in very low volumes. Enhancements are sometimes transitioned from the laboratory to the factory without a complete understanding of producibility constraints. Therefore, MDA is interested in innovative product enhancements that improve consistency and manufacturability while incorporating evolving technologies for integration into MDA systems. Intended enhancements range from improvements in fabrication of advanced materials to innovative components and processes that improve the capability of current systems. The goal is to enhance producibility of power sources as used in missile defense products, reduce unit cost and improve product reliability and performance to support future capabilities. For this solicitation, areas of interest include (but are not limited to) the following:

Improved Manufacturing & Production: Main interest areas include improving processing techniques to lower power source production costs and enhance performance (e.g. apply modern production technology to heritage processes), eliminating or modifying process steps that induce undesirable characteristics, and innovative software-based tools (e.g. battery design and production models, process CAM/CAD) to aid manufacturers with battery design and production monitoring. Other interest areas include innovations that reduce nonrecurring engineering costs, shorten lead times, and produce lighter, safer, and less expensive cells and batteries. Improvements that enhance production yield, consistency, reliability, producibility and manufacturability are desirable necessities for overall mission success.

Primary Reserve Batteries for Missile Applications: Two main interest areas are new and improved reserve battery manufacturing techniques; innovations that result in batteries with higher energy and/or power density (e.g. average specific power of greater than 3 kW/kg, specific energy greater than 200 Whr/kg at the battery level). Other desired improvements include models and simulations of activation dynamic conditions in reserve batteries, enhancing conformability to allow fitting batteries into unconventional shapes for efficient space utilization (e.g. shapes other than right cylindrical or rectangular solids), improving battery safety under normal and abnormal use conditions (e.g. fire exposure); reducing “touch labor” during fabrication, improving subcomponents used in these batteries (e.g. high efficiency insulations, advanced materials for use in thermal batteries), reducing parts count and simplifying fabrication techniques to reduce cost and complexity (e.g. easier to assemble battery subcomponents).

Aerospace-grade Secondary Lithium Batteries: Two main interest areas for rechargeable lithium batteries are improved manufacturing techniques and developing reliable, lower cost manufacturing processes for optimal cell designs with resulting battery configurations that can accommodate long duration space missions (e.g. low earth orbit, medium earth orbits for up to ten years calendar life). An additional interest area is smaller rechargeable Li-ion cells (e.g. 2 Amp hr) cells that are suitable for use in missiles at moderate power levels (e.g. kW/kg) and high energy levels (e.g. >200 Whr/kg at cell level). These interest areas include achieving long-term available and consistent materials as used in rechargeable lithium cell production, beneficial variations to space-quality lithium rechargeable cells that enable them to achieve moderate to high charge and discharge rates with suitable voltage characteristics (e.g. discharge at 10C rates), improved calendar life; increased cycle life at greater depths of discharge (e.g. over 20,000 cycles at >50% depth of discharge); improved charging and cell balancing methods; software models that allow cell and battery life-cycle simulation (voltage decay, capacity fade, response to limited over charging, thermal exposure, etc.) to help achieve confidence in cell and battery designs, and improving cell safety (e.g. benign response to abusive conditions like over charging, over discharging).

Aerospace Grade Nickel-based Batteries. Current Nickel-Cadmium (NiCd) batteries used for MDA target and other BMDS missile applications are based on commercial NiCd cells. The small demand for NiCd cells capable of use in aerospace applications has resulted in multiple source-of-supply and other changes over the last five years. MDA applications require relatively small numbers (e.g. in the low hundreds) of small sized (e.g. 1 to 10 Amp hr) cells. A main focus for this topic area is to develop suitable innovations that will help manufacturers provide these needed cells long-term with the requisite quality and ability to withstand aerospace temperatures (-25C to +60C operating) and vibration, shock, acceleration environments (e.g. MIL-STD 1540). Another focus area is to develop suitable replacements for existing NiCd based batteries that exhibit combinations of benefits that include improved cell availability, reduce weight, lower cost, reduced hazards (materials and behavior) and reduced volume over batteries constructed with commercial NiCd cells. Example innovations include right-sized production processes, raw material and other supply chain improvements, adopting other cell types and configurations into batteries for use in these applications.

PHASE I: Develop conceptual framework for battery or battery production process design/design modification, and manufacturing processes, for integration into MDA systems or subsystems to increase performance, lower cost and increase reliability and producibility. Where possible, limited scale demonstrations should be provided to assist in the judging of merit of the new technology.

PHASE II: Validate the feasibility of the power generation and storage device or manufacturing process technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation by demonstration should sufficiently show near term application to one or more MDA-interest systems. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable. The possibility of commercial benefit or application opportunities for the innovation is desirable.

PHASE III: The intention is to successfully implement the new power storage technology for use by MDA and other customers as appropriate. Implementation would include, but not be limited to, demonstration in a real system or operation in a system level test bed, and flight testing of the battery concepts. The new power source technology should be implemented at a manufacturer and be ready for inclusion in MDA applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: MDA uses different types of power storage devices. Thermal primary batteries are used in military and commercial launch vehicles to power various subsystems in-flight. Lithium oxyhalide (active type) batteries are also used for some commercial applications and may be capable of replacing other battery types (e.g. where weight is a factor). Rechargeable batteries are used in aerospace applications for on-board power and are also widely used in commercial applications. Finally, the manufacturing and producibility enhancements for MDA batteries could be applicable to commercial battery manufacturing lines.

REFERENCES:
1. http://www.acq.osd.mil/mda/mdalink/html/mdalink.html provides an overview of MDA platforms.

2. http://www.eaglepicher.com/EaglePicherInternet/Technologies/Power_Group/Defense_Applications_Products_Services provides documents describing MDA-interest batteries and related technology.

3. http://www.lithion.com/lithion/index.html provides links to various documents describing MDA interest rechargeable lithium battery technology.

4. http://www.sandia.gov/news-center/resources/tech-library/index.htm provides links to documents (some detailed) describing various MDA-interest battery technologies.

5. http://www.electrochem.org provides detailed information on current state-of-the-art advances and research, mainly for MDA-interest rechargeable batteries.

6. Handbook of Batteries, 3rd Edition, McGraw-Hill, provides detailed information regarding the design and construction of thermal, liquid reserve and rechargeable batteries.

7. van Schalkwijk and Scrosati, Advances in Lithium-Ion Batteries, Kluwer Academic / Plenum Publishers, 2002.

KEYWORDS: power density, energy density, conformability, battery, lithium, rechargeable, space, Nickel Cadmium, Nickel Metal Hydride

MDA08-023 TITLE: Radiation Hardened Producible Manufacturing

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: DEP, GM, KI, KV, SS, AB, TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to increase the radiation hardness/survivability of electronics manufacturing through innovative approaches in design, modeling and simulation, materials, production processes and capabilities, advanced shielding material and/or novel approaches in combining these factors for Ballistic Missile Defense System (BMDS) applications. Of particular interest is to simulate a radiation hardened tool allowing fabrication of advanced semiconductor devices without the need for resist thereby avoiding high front-end, fixed costs. The goal of this topic is to provide an increased level of resistance to damage of electronics/semiconductor components induced by nuclear environment radiation without a negative impact on weight, performance or product availability.

DESCRIPTION: The BMDS must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, space radiation, etc.). Systems must also survive and function after prolonged periods in battlefield/storage environments. Optimal utilization of mass in missile systems and space platforms precludes exclusive reliance on traditional shielding methods as a means of countering the adverse effects of radiation. MDA is seeking the development of innovative concepts that use radiation-hardening by process, by isolation, by design, by simulation, by architecture or a combination of these approaches. They will allow systems to endure and reliably operate in BMDS mission environments (radiation, shock, vibration, thermal, etc) without increasing weight or decreasing performance. Systems of interest include all BMDS kill vehicles and space-based platforms.

The continuing increase in performance in microelectronics is made possible by the steadily decreasing size of transistors, summarized in the popular press as Moore's law. The present methods to mitigate radiation effects while proven to be effective at circuits geometries below 150 nanometer (nm) have been shown to be less effective when applied to integrated circuit feature sizes below 65 nm. The development of such methods requires the development of cost effective methods to model and simulate the radiation response of these less than 65 nm semiconductor technologies. Current semiconductor manufacturing techniques utilize masked lithography and resist covered semiconductor wafers resulting in complex and expensive mask structures at these smaller feature sizes. The resistless approach bypasses the requirements for the tapeout, and the entire wafer preparation/clean process for lithography on each level. Eliminating these steps opens the door to flexible, scalable and distributed manufacturing to effectively reduce the up-front fixed costs; thus broadening the United States semiconductor industry. This approach is particularly suited for low production rates (e.g. tens of wafers) and therefore should address advantages in radiation hardened semiconductor processing. The basic requirement for a resistless manufacturing tool is a throughput of at least one wafer (300 mm dia.) completed per day with features below 65 nm. Overlay accuracy and dimensional control are to be compatible with the usual conventional semiconductor manufacturing requirements applicable to a given feature size. Exposing beams may be photons or charged particles.

Technical areas of interest include: advanced designs and materials, composite materials with shielding layers, coatings, design simulation and modeling, mitigation algorithms and techniques, and production processes and capabilities. The use of Technology Readiness Levels to describe current technology maturity will be helpful in evaluating the planned effort. This topic's focus is on innovations that are producible and can be inserted into all missile defense systems.

PHASE I: Define component simulation approach and architecture. Identify key modeling subcomponents. Evaluate approach for throughput, feature size, overlay, dimensional control, critical charge deposition energy and device capture cross section with statistically significant correlation to manufacturing data. Develop accurate and cost effective radiation effects physics-based computational modeling and simulation methods for below 65 nm semiconductor devices and integrated circuits. Conduct research and experimental efforts to identify, investigate, and demonstrate materials, unique device designs, novel architectures, and/or production process changes that address reliable operation of BMDS systems in perturbed environments. Determine feasibility of radiation hardening components and/or subsystems using proposed concepts without sacrificing performance characteristics while achieving a reduction or net zero impact in mass. A sound basis must also be shown for the radiation hardness capability of the treatment. Where ever possible, modeling, simulation, analysis, and/or testing should be performed to support conclusions. Consider implications for practical implementation of proposed concepts. Offerors are strongly encouraged to work with system and payload component manufacturers to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Using the resulting radiation hardened materials, techniques, designs, Technology Computer Aided Design (TCAD) tools, production and/or process changes or additions in Phase I then implement, test and verify the proposed concept in prototype fashion to demonstrate feasibility and efficacy. Validation would include, but not be limited to: BMDS simulations, operation in test-beds, operation in a demonstration sub-system, and/or radiation testing. For the resistless fabrication tool, provide a detailed simulation for complete manufacture meeting the above requirements. Fabricate a minimum model, and demonstrate feature size, overlay, dimensional control, and scalability for throughput of at least one wafer level per hour. The offerors are encouraged to further seek partnerships with nano electronics manufacturers or production cluster tool vendors as appropriate.

PHASE III: The technology developed will apply to integrated circuit designs having the relatively low production volumes of the BMDS or Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and the initial engineering lots developed for high volume commercial markets. There may be opportunities for the advancement of this technology for use in both commercial and military space activities during phase III program. Partnership with traditional DoD prime-contractors will be pursued as government applications can receive benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial electronics potential exists in the medical community, homeland security sector, and power and automotive industries. Certain technology developed will have a significant impact on the breakthrough application of advanced commercial nano electronics manufacturing market. These less than 65 nanometer features are increasingly more susceptible to single event effects and this topic will assess quality control features within new devices to assure uniform radiation hard manufacturing producibility.

REFERENCES:
1. Glastone, Samuel, The Effects of Nuclear Weapons, USAEC, USGPO, Washington D.C., 1957.

2. http://public.itrs.net/

3. R. Reed, et al., “Impact of Ion Energy and Species on Single Event Effects Analysis,” IEEE Trans. Nucl. Sci., Vol. 54, Dec. 2007, pp. 2312-2321.

4. K. M. Warren, et al., “The contribution of nuclear reactions to single event upset cross section measurements in a high-density SEU-hardened SRAM technology,” IEEE Trans. Nucl. Sci., vol. 52, Dec. 2005, pp. 2125–2131.

5. C. L. Howe, et al., “Role of Heavy-Ion Nuclear Reactions in Determining On-Orbit Single Event Error Rates,” IEEE Trans. Nucl. Sci., vol. 52, Issue 6, part 1, Dec. 2005, pp. 2182-2188.

KEYWORDS: radiation effects, radiation hardening, materials, space radiation, lithography, resistless processing, direct-write, radiation hardening, semiconductor fabrication, manufacturing, producibility

MDA08-024 TITLE: Advanced Nitride Heterostructures for X-Band GaN HEMTs

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: DEP, SN

OBJECTIVE: Develop and demonstrate Al1-xInxN materials suitable for high frequency, high power AlInN/GaN HEMT operation.

DESCRIPTION: Wide bandgap semiconductors, namely GaN, have expanded the scope of device applications beyond those of silicon and gallium arsenide. Exploitation of GaN semiconductors holds promise for revolutionary improvements in radar performance. While significant progress has been made in the development of high power AlGaN/GaN devices, strain-induced defects inherent for Al compositions >30% produce a physical limit on device performance. While theory has predicted improved HEMT performance for AlInN barrier layers over the current AlGaN design, past inability to successfully fabricate high quality AlInN layers, which uniquely can be grown strain-free on GaN, has resulted in unrealized utilization of these materials. AlInN materials offer improvements to conventional AlGaN/GaN HEMTs for high frequency, high power applications. Successful materials development and characterization could enable unprecedented power and frequency performance.

PHASE I: Develop growth parameters for Al1-xInxN films on 3-inch substrates. Identify defects in films and compare defect energy levels to those found in conventional AlGaN/GaN films. Deliver epitaxial materials for Government evaluation.

PHASE II: Demonstrate stoichiometric control over Al1-xInxN film growth. Demonstrate pseudomorphic HEMT structures with room temperature μ > 1200 cm2/V•s, ns > 2.5 x 1013 cm-2, ?s < 250 O/sq with wafer uniformity < 5% over a 3-inch substrate. Identify role of defects and lattice mismatch on carrier density and mobility. Fabricate HEMT devices with fT > 130 GHz. Deliver epitaxial materials for Government evaluation. Identify radar components suitable for insertion utilizing proposed technology.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposed technology is expected to garner a high level of interest for next generation RF power amplifiers.

REFERENCES:
1. Kuzmík, J., “Power Electronics on InAlN/(In)GaN: Prospect for a Record Performance,” IEEE Electron Device Letters, VOL. 22, NO. 11, November 2001.

2. Blevins, J., “Wide Bandgap Semiconductor Substrates: Current Status and Future Trends,” Compound Semiconductor Manufacturing Technology Conference, May 2004, Miami.

KEYWORDS: AlGaN, InAlN, AlInN, GaN, HEMT, power, wide bandgap semiconductors, defects, growth, materials

MDA08-025 TITLE: High-Power RF-MEMS Phase Shifters for Phased-Array Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate high-power Radio Frequency Micro Electro-Mechanical Systems (RF-MEMS) phase shifters for X-band phased array applications.

DESCRIPTION: Modern active electronically scanned phased array radars provide outstanding capability but are unfortunately expensive. To a large degree, this results from the need for power and low noise amplifiers at each antenna element. A promising alternative architecture shares the amplifiers among many elements and thus requires a phase shifter at each element. This choice imposes challenging power handling and insertion loss requirements on the phase shifter.

The RF MEMS switch, in various physical implementations, has been offered as a critical control component for use in phased-array radars employing digital phase shifters. RF-MEMS-based phase shifters bring the potential of low insertion loss per bit and ultra-linear performance while requiring very low operating power. Recent demonstrations of lifetime in contact switches [1] and in the understanding of factors that lead to dielectric charging in capacitive switches [2] and the impact of switch failure on array degradation [3] have demonstrated that the reliability issues that have delayed insertion of these devices into real systems are much closer to being solved. This progress in RF MEMS device development now makes radar system concepts supporting BMD feasible.

It can be expected that device improvements that build on proven device designs will lead to a laboratory demonstration of reliable RF MEMS phase shifters exhibiting increased power handling and lower insertion loss. The goal of this program is to utilize RF MEMS devices having improved reliability in X-Band (8-12 GHZ) phase shifter networks. Successful proposals will support a 4-channel phase shifter network composed of a single RF input divided into 4 independent phase-shifted output channels, at output power levels of > 5W peak/channel, > 2W average/channel, switching delay of < 5 microseconds, phase resolution > 4-bits over a full cycle, and < 2 dB insertion loss between the network input and the output of each phase shifter channel.

PHASE I: Demonstrate, using test results of the performance of suitable RF MEMS switches, along with reasonable expected improvements in device characteristics and simulations of phase shifter circuits, that the 4-channel phase shifter network having the specifications listed in the description above may be successfully fabricated.

PHASE II: Fabricate, test, and deliver one 4-channel RF-MEMS high power phase shifter network in a conventional connectorized microwave fixture, meeting the specifications of Phase I, along with a compatible control interface suitable for laboratory demonstration.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology is expected to result in a high level of interest in these circuits for current and future generation phased-array radar systems.

REFERENCES:
1. H. S. Newman, J. L. Ebel, D. Judy, and J. Maciel, “Lifetime Measurements on a High-Reliability RF-MEMS Contact Switch,” IEEE Microwave and Wireless Components Letters, Vol. 18, No. 2, 2008.

2. X. Yuan, Z. Peng, J. C. M. Hwang, D. Forehand, and Charles L. Goldsmith, “Acceleration of Dielectric Charging in RF MEMS Capacitive Switches,” IEEE Transactions on Device and Materials Reliability, Vol. 6, No. 4, 2006.

3. J. Teti, and F. Darreff, “MEMS 2-bit Phase-Shifter Failure Mode and Reliability Considerations for Large X-Band Arrays,” IEEE Trans. Microwave Theory and Tech., Vol. 52, No. 2, pp. 693-701, 2004.

KEYWORDS: RF-MEMS, phase shifters, phased-array radar, switches.

MDA08-026 TITLE: Multistatic Sea-Based Radar Concepts and Architectures

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: DV

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foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Conduct research and development of multi-static sea-based radar registration and communication methods, along with aperture alignment , and coherence methods to support multi-seabased radar sensor target tracking, taxonomy (identification) and fire control.

DESCRIPTION: Effective sea-based multistatic, geometrically separated radar operations increase battlespace effectiveness through improved detection, tracking, and identification. However, in multistatic radar applications, the radar signal processing, beam and waveform control algorithms are sensitive to rotational and translation registration errors. These errors are often introduced by incomplete communication or registration resulting from limited or legacy methods for mobile platforms at sea. Innovative concepts are sought in the fields of information communications and radar signal processing that desensitize multistatic systems from these errors. Communications solutions may address research and development of specific communication methods, systems, required messages, latency and quantization requirements and registration parameters. Radar signal processing solutions may address research and development in waveforms, ambiguity functions and coherence methods that will work on sea based sensors. Approaches can be verified using sensitivity and error analysis. Examiners should assume legacy and evolving platform translational and rotational accuracies as given in the table below. These ranges are provided for guidance.

Parameter:	Value:
Ship Platform Inertial Position	~10m position
Velocity	~ 0.2 m/s velocity
Attitude knowledge	~ 0.4 to 1 mrad attitude
Common time Reference	WGS-84 UTC (sec) slaved to GPS 0.01 msec error
Intership digital data transfer system	64 bit float point w sign 1 Hz update ~1-10 sec latency

PHASE I: Develop and demonstrate the feasibility of the proposed algorithms, concepts and architectures that address the specific needs identified in this topic. Demonstrations can be through hardware or models and simulations.

PHASE II: Develop and demonstrate prototype technologies in a laboratory environment which meet or exceed missile defense requirements for multistatic radar interfacing. Conduct hardware and/or software tests to evaluate the performance of the technology.

PHASE III: Integrate technology into missile defense systems and demonstrate enhanced performance through multistatic sea-based radar configurations in realistic environments or in a system-level test bed. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposed technology is expected to provide enhancements to the architectures of radar systems through improved detection, parameter estimation, tracking, and identification. These will garner a high level of interest for next generation communications and signal processing applications along with direct use in commercial radar applications.

REFERENCES:
1. Roggemann, Michael C., Multiple Sensor Fusion for Detecting Targets in FLIR (Forward-Looking Infrared) and Range Images, AFIT, DTIC ADA207577.

2. Humali, I. G., Sensor Fusion for Boost Phase Interception of Ballistic Missiles, NPS, DTIC ADA427181

3. Jelalian, A.V., Laser Radar Systems, Artech House, Inc., 1992

4. Kamerman, G. W., Laser Radar, Chapter 1, Vol. 6, The IR and EO Systems Handbook, SPIE, 1993.

5. Miller, J. L., Principles of Infrared Technology, Chapman & Hall, 1994.

6. Acceta, J. S., and D. L. Shumaker, The Infrared and Electro-Optical Systems Handbook," SPIE Optical Engineering Press, Bellingham, Washington, 1993.

7. Schilling, B. W., et al., Multiple Return Laser Radar for 3-D Imaging Through Obscurations, Appl. Optics, 41, 2791 – 2799, 2002.

8. SHIPS-R 5990, "RLGN AN/WSN-7 Inertial Navigation Specification," Unclassified Supplement, Rev. 2.0 July 5, 1998.

KEYWORDS: Sensor, Radar, Signal Processing, Fusion, Distributed Apertures, Adaptive Processing, Multistatic Radar.

MDA08-027 TITLE: Wideband Beamformer

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To design a steerable wideband RF beamformer that provides 10 or more simultaneous independent RF beams for a 2:1 bandwidth phased array antenna.

DESCRIPTION: This topic involves the development of novel approaches to design, develop and fabricate a 2:1 or greater octave RF beamformer for a phased array antenna. This beamformer must also provide 10 simultaneous independent beams or more, with a minimum scan of +/- 60 degrees for each beam. Historically, typical switched beam systems consisted of a phase shifting network, an RF switch, control logic and a detector. Two variants have included Butler and Blass matrices, each with specific advantages and disadvantages. Currently, digital and optical beamformers are being studied to solve this problem. The digital approaches to a wideband array require a massive amount of RF and Digital hardware. The optical approaches are able to handle multiple Gigahertz bandwidth in each beam. However, fairly significant RF conversion losses have typically been associated between the input and outputs of the optical system. Recent advances in component materials, matrix and processing techniques may be able to minimize losses. The beamformer can be designed as receive only or combination transmit and receive system, with a combination system desired. One dimensional scan of a phased array is acceptable with a 2 dimensional scan desired. Instantaneous bandwidth greater than 60 MHz. However, an instantaneous bandwidth covering the full range of octaves are desired. Trade space analysis of potential implementation technologies.

PHASE I: Perform trade space analysis of potential implementation technologies. Develop initial design concept; conduct analytical and experimental efforts to demonstrate proof-of-principle; develop preliminary design complete with documentation that will provide proof-of-functionality; and model or produce/demonstrate " breadboard operational prototype" to ensure proof of basic design concept.

PHASE II: Design and fabricate a prototype structural concept that could be demonstrated in a representative environment. The goal is to transition and commercialize this technology by developing working relationships with the relevant electronic warfare systems and contractors.

PHASE III: Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL: A large commercial potential exists for highly integrated/synergistic structures in the aerospace, automobile, and infrastructure industries.

REFERENCES:

1. Antenna Engineering Handbook, Johnson and Jasik.
2. Phased Array Antenna Handbook, R.J. Mailloux.

KEYWORDS: Wideband RF beamformer, Blass matrix, True time delay beamforming, Butler matrix beamformer, Switching networks.

MDA08-028 TITLE: Wideband Sub-Array Digital Receiver Exciter (DREX) Development and Packaging

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: GM

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OBJECTIVE: Develop and demonstrate wideband DREX technology for next generation X-band Radar Systems.

DESCRIPTION: Next Generation BMD X-Band Radar Systems are anticipated to utilize highly digitized sub-arrayed digital beam-forming (DBF) architectures. This type of architecture will require multiple DREX channels, scalable from 10s to 100s of channels. Cost, Size, Weight, and Power (CSWAP) of current state-of-the-art Radar DREX technology make implementing these highly digitized architectures prohibitively expensive. Recent developments in commercial wideband direct RF/IF conversion Analog to Digital Converters (ADCs), Digital to Analog Converters (DACs), highly integrated mixed signal RF front-ends, and low-power / high density signal processing hardware such as Field Programmable Gate Arrays (FPGAs) enable the possibility of affordable, low-power, low SWAP DREX channels. For the purposes of this topic the receive portion of the DREX takes X-band RF signals as an input and outputs digitized In-phase and Quadrature (I&Q) data. The receiver should cover a 25-40% operating bandwidth centered at X-band. The receiver should cover a tunable instantaneous bandwidth of 1GHz (goal), 200MHz (threshold), with an instantaneous dynamic range of 50+ dB. For the exciter portion, a digitally programmable waveform generation capability is desired (eg. frequency modulated, phase coded, arbitrary). The input is a digital (software) description of the desired waveform properties and the output is the X-band synthesized waveform. Exciter Instantaneous bandwidth goals are similar to the receiver. The goal for quantity production of a single scalable DREX channel is a cost <$20K, volume of <20cu inches, and power consumption of <20 watts. The architecture and interfaces should utilize open system (OS) principles to the maximum extend feasible to enable ease of integration and scalability.

PHASE I: Develop and demonstrate innovative DREX architectures, and device designs for low power DREX components supporting X-band radar. Key components should be identified and DREX architectures trades should occur resulting in selection of the best architecture and /or components for development in Phase II. The output of phase 1 is a behavioral analysis of proposed architecture and/or key devices. The contractor shall document specifications for the selected DREX architecture and key components.

PHASE II: Validate performance, cost and reliability benefits to be achieved through a prototype device and/or prototype DREX system demonstration. The prototype demonstration will show advancement over current state of the art for DREX components in terms of performance (bandwidth, dynamic range..), reduced CSWAP or increased flexibility (software programmability). Benefits of the implemented approach will be measured and quantified. Identify radar components suitable for insertion utilizing proposed technology. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Refine prototype components and / or DREX developed in Phase II for targeted MDA and commercial applications. Work with MDA to target potential integration into one or more BMDS systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology has a number of related commercial applications in radio frequency (RF) sensors. Commercial radar systems, commercial RF communications systems (e.g. Telecom, SATcom), all require DREX and have increasing needs for wideband low power, highly digital (flexible) DREX technology.

REFERENCES:
1. T. Quach et al, “X-Band Receiver Front-End Chip in Silicon Germanium Technology”, IEEE 8th Topical Meeting on Silicon for RF Systems, Jan 2008.

2. R. Dragenmeister et al, “Multi-Chip-Module Based X-Band Receiver Utilizing Silicon Germanium MMICs”, GOMACTECH 2008, Mar. 2008.

3. RFI-08-01-PKSE, Request for Information, “Digital Receiver/Exciter (DREX) Technology Capabilities”, November 2007.

KEYWORDS: Digital Receiver, Analog to digital converter, direct digital synthesis, radar receiver, Digital Beam Forming, waveform generation, phased array radar.

MDA08-029 TITLE: Wide Bandgap Semiconductor Power Inverters and Converters for Next Generation Transmit Receive (T/R) Module Power Supplies

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate wide bandgap semiconductor electronic components for supporting high voltage operation of next generation X-band T/R modules.

DESCRIPTION: The intrinsic properties of gallium nitride (GaN) make it ideal for use in next generation microwave/millimeter wave radar applications. T/R modules based on GaN HEMT power amplifiers have the capability of operating at higher voltages (~48V) relative to gallium arsenide (GaAs) –based systems and thus place new demands on the module power supplies. The unit supplying power to the module must support the voltage, current draw, and transients associated with the rapid switching between the transmit and receive states of the module. Silicon (Si) -based MOSFETs and diodes are typically used in the inverters and converters in the power supply, yet they are limited in switching performance. Silicon carbide (SiC) and GaN-based electronic devices exceed the power handling capabilities of silicon and have excellent materials properties for high power applications. Use of wide bandgap semiconductors power switching devices could improve system performance and efficiency by enabling switching frequencies exceeding 500KHz, 20% reduction in power conversion loss, adaptive digital control, reduced size and weight and increased level of integration. As a result, MDA radar systems would benefit from the development of wide bandgap power semiconductors supportive of high voltage operation of next generation GaN-based T/R modules. Innovative material and device solutions supporting power supplies for GaN based T/R module technology.

PHASE I: Develop and demonstrate innovative materials and device designs for power inverters and converters in power supplies supporting X-band radar.

PHASE II: Validate performance, cost and reliability benefits to be achieved through a prototype device demonstration. Identify radar components suitable for insertion utilizing proposed technology. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems. Partnership(s) with current or potential supplier(s) of MDA system components is highly desirable

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology has a number of related commercial applications in power electronics, including satellite power systems, electric grid power generation and distribution, switching power supplies, motor drives, and hybrid electric vehicle electronics.

REFERENCES:
1. Palmour, J., “Energy Efficient Wide Bandgap Devices”, IEEE CSIC Symposium, 2006.

2. Blevins, J., “Wide Bandgap Semiconductor Substrates: Current Status and Future Trends,” Compound Semiconductor Manufacturing Technology Conference, May 2004, Miami.

KEYWORDS: Inverter, converter, wide bandgap semiconductors, GaN, power amplifiers, phased array radar.

MDA08-030 TITLE: Calibration techniques for very large arrays

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

ACQUISITION PROGRAM: GM

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OBJECTIVE: The objective of this effort is to develop calibration techniques for very large x- band phased arrays. These x-band phased arrays will be larger than 10 square meters.

DESCRIPTION: Very large x-band phased arrays are being proposed for a variety of functions including ballistic missile detection and tracking, Space Based Radar, and Near Space Based Systems. These arrays are built up from Sub array panels on the order of .25 to .5 square meters. Each sub array or panel may have as many as 1000 elements or more. To effectively scan a beam all elements in the array must be phased properly to electronically form a beam at the desired angle. There are many error sources that can occur in this process, these include but are not limited to; panel alignment, fabrication errors, failed elements, thermal expansion vibrations from the pedestal and or air vehicle. To perform this calibration by sequentially adapting each element in the array will take a large amount of time. Other efforts based on measuring the array shape using fiber optics, photogrammetric methods, and algorithmic processing methods have been demonstrated on smaller arrays and parabolic antennas but have not been demonstrated on arrays incorporating tens of thousands of elements. Under this effort the contractor should propose techniques that can be implemented to reduce the time to calibrate the array and can adapt to varying conditions. The calibration technique should also have a minimum impact on the phased array hardware.

PHASE I: Develop initial design concept; conduct analytical and experimental efforts to demonstrate proof-of-principle; develop preliminary design complete with documentation that will provide proof-of-functionality; and model or produce/demonstrate " breadboard operational prototype" to ensure proof of basic design concept.

PHASE II: Design and fabricate a prototype structural concept that could be demonstrated in a representative environment. The goal is to transition and commercialize this technology by developing working relationships with the relevant electronic warfare systems and contractors

PHASE III: Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for highly integrated/synergistic structures is immense in the aerospace, automobile, and infrastructure industries.

REFERENCES:
1. Beck, F. B Antenna pattern corrections to microwave radiometer temperature calculations, Radio Sci., 10, 839-845, Oct 1975.

2. Collin, R. E. Field Theory of Guided Waves, Sec 5.3, McGraw Hill, New York, 1960.

3. Croswell, W. F. and M. C. Bailey, Radiometer antennas, in Antenna Engineering Handbook, 2nd ed., chap 31 edited by Johnson and Jasik, McGraw-Hill, New York 1984.

4. Collin R.E., Antennas and Radio Propogation, Section 5.5, McGraw Hill, New York, 1985.

5. Samjeva, Ishan and Daniel Solomon, Douglas A. Gray, "Receiver Array Calibration Using Disparate Sources", IEEE, TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 47, NO. 3, MARCH 1999.

6. Lam, Larry K., and Walt S. Gregorwich, and Steve A. Horn. "S-band electronically scanned active phased array antenna"- Aerospace Conference Proceedings, 2000 IEEE.

7. Ron Sorace, "Phased Array Calibration", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 49, NO. 4, APRIL 2001 517.

KEYWORDS: Calibration, Large phased arrays, sources, algorithms, timeline, repeatability, uncertainty, alignment, metrology.

MDA08-031 TITLE: Innovative Hardware Technologies for Anti-Jam and Electromagnetic Attack Rejection in Ballistic Missile Defense System (BMDS) Radars

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: GM

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OBJECTIVE: Identify, develop, and demonstrate novel or innovative advances in anti-jamming and electromagnetic attack protection hardware technologies that will support existing BMDS X-band, S-band, and other radar systems as well as communication and GPS systems. The focus of this research is to develop and demonstrate hardware technologies that provide protection and/or mitigation of the radar from jamming, high power microwave (HPM), ultra wide band (UWB), and electromagnetic pulse (EMP) attacks and at the same time improve signal-to-noise ratio (SNR) with minimal insertion loss.

DESCRIPTION: The BMDS radar threats envisioned for the near- and far-term are a challenging mixture of electromagnetic threats that include jamming, high power microwave attack, ultra wide band attack, and electromagnetic pulse attack among other countermeasures. These threats will require novel and innovative hardware solutions to protect the front end receivers of radars and communication systems. This technology research effort is focused on developing and demonstrating hardware technologies to defeat evolving advanced Active Electronic Counter Measures (ECM) and high-power (> 10 kW/cm2), fast-rise-time (< 5 ns) HPM, UWB, or EMP attacks through the radar front end. New hardware technologies that provide improved protection for existing BMDS radars and communication systems and improved will be developed. Key areas of research interest include pulse limiters, advanced noise filtering devices, as well as other hardware devices for increasing signal-to-jamming or signal-to-clutter ratios. Of particular interest are passive devices capable of increasing the signal-to-noise ratio and/or providing the required ECM/HPM/EMP protection. Proposed approaches should include details of assumptions that impact the overall system performance or are required to facilitate the incorporation of the proposed technology. All designs must be based on and all testing must be done using generaic or commercially available radar systems.

PHASE I: Develop and demonstrate the feasibility of the proposed technologies for anti-jam and/or HMP/UWB/EMP protection. Demonstration of the technology with either a brassboard or pre-prototype is preferred.

PHASE II: Refine/update concept(s) based on Phase I results. Evaluate/demonstrate the technology in a realistic laboratory environment using commercially available radar/communications systems to show the enhanced protection and SNR capability provided by the technology.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed. This demonstration should show near-term application to one or more BMDS radar systems. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to commercial air traffic control radar and commercial communications systems for anti-jam and EMI protection as well as protection of commercial equipment from EMP/HPM/UWB by terrorists groups. There also are numerous military applications outside of missile defense.

REFERENCES:
1. “Information Warfare Technology,” http://www.jya.com/mcsec09.pdf

2. Eileen M. Walling, “High Power Microwaves: Strategic and Operational Implications for Warfare,” Occasional Paper No. 11, February 2000, Center for Strategy and Technology, Air War, College, Air University, Maxwell Air Force Base, Alabama, http://www.globalsecurity.org/military/library/report/2000/occppr11.htm

3. John S. Foster, Jr., et al., “Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack,” Volume I: Executive Report, 2004, http//www.globalsecurity.org/wmd/library/congress/2004_r/04-07-22emp.pdf

4. Li Neng-Jing and Zhang Yi-Ting, “A Survey of radar ECM and ECCM,” IEEE Transactions on Aerospace and Electronic Systems, Volume 31, Issue 3, July 1995, pp. 1110-1120.

5. Chung-Yao Chang; Shiunn-Jang Chern, “Adaptive linearly constrained inverse QRD-RLS beamformer for multiple jammers suppression”, Wireless Communications, 2001. (SPAWC '01). 2001 IEEE Third Workshop on Signal Processing Advances, 2001, pp. 294–297.

6. A. Kikel, L. Altgilbers, I. Merritt, M. Brown, L. Ray, and T. Zhang, “Plasma Limiters,” AIAA Paper, AIAA-98-2564, 1998.

7. Todd B. Hale, “Airborne Radar Interference Suppression Using Adaptive Three-Dimensional Techniques,” Storming Media, Report A755204, 2002.

8. Gaoming Huang and Luxi Yang, “A Radar Anti-Jamming Technology Based On Blind Source Separtation,” 2004 Proceeding ICSP’04 Signal Processing, 2004.

9. J. Benford, J.A. Swegle, and E. Schamiloglu, High Power Microwaves, 2nd Edition, CRC Press (2007).

KEYWORDS: Anti-Jam, Electromagnetic Interference, Electromagnetic Pulse, High Power Microwave, Radar, X-Band, Electronic Countermeasures, Ballistic Missile Defense

MDA08-032 TITLE: Integrated UV/VIS/IR background phenomenology models for radiation transport system trades

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: DE

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OBJECTIVE: Develop advanced software algorithms and architecture to create integrated, unified and consistent terrain and cloud background models for battlespace ultraviolet, visible and infrared system trade studies.

DESCRIPTION: Next generation ballistic missile warning, defense and surveillance systems need to anticipate, through modeling and simulation, the background ultraviolet (UV), visible (VIS) and infrared (IR) radiation battlespace environment, including geometries that intercept cloud and terrain backgrounds. This objective requires prior knowledge of the environmental radiance conditions for development of optimal sensors and detection approaches. Much work has been done to create atmosphere, terrain and cloud background models (see references below), but what is needed is an architecture that efficiently and seamlessly unifies existing, improved, and/or new computer code in a consistent and fully integrated computer environment. Proposals are sought for developing an innovative capability to improve terrain and cloud simulations and integrate the new models into state-of-the-art background radiation codes, such as the Air Force SAMM2 and FLITES codes and Navy SSGM code to meet missile warning/defense surveillance needs. Proposed advances should address issues related to determining the state of the terrain and clouds from UV, VIS and IR imagery, using arbitrary spatial resolution that is commensurate with, but not limited to, airborne and satellite imagery, and producing simulations as seen by UV, VIS and IR sensors through radiative transfer modeling. SAMM2, FLITES and/or SSGM should serve as a baseline for implementation. Other key features should address computational speed for operational implementation, computer platform flexibility, ease of subsequent model upgrades, and error/uncertainty estimates in simulating airborne and satellite imagery. Validation should be accomplished through imagery provided by UV/VIS/IR airborne and satellite sensors.

PHASE I: Define robust terrain and cloud components. Define an architecture detailing how these components can be efficiently, seamlessly and consistently integrated into an existing computer modeling environment such as SAMM2, FLITES and/or SSGM, or define how these existing computer environments can be integrated into a new architecture that supports the new or improved terrain and cloud components. Prototype a robust and viable computer code for simulating terrain and cloud UV/VIS/IR imagery and demonstrate the algorithms for UV/VIS/IR remotely-sensed ground terrain and cloud scenes. Establish a plan for validating the simulations.

PHASE II: Evolve the approach developed in Phase I into a fully implemented UV/VIS/IR radiance simulation capability. Demonstrate the potential and feasibility of the software for real world airborne and satellite mission scenarios, including seasonal effects, in coordination with government personnel. Provide error/uncertainty estimates of the UV, VIS and IR imagery simulation capability using well-defined statistical measures. Validate the code and simulations.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II capabilities to meet individual system applications. The first use of this technology is envisioned for space tracking and surveillance systems trades.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Military application: The technology will provide a system trade capability for UV/VIS/IR imagery that will enhance sensor capability and intelligence mission planning surveillance. Commercial application: Results from this work will apply to weather forecasting and future NASA earth science missions.

REFERENCES:
1. H. Dothe, J.W. Duff, J.H. Gruninger, P.K. Acharya, A. Berk, and J.H. Brown, “USERS' MANUAL FOR SAMM-2, SHARC-4 and MODTRAN-4 MERGED, AFRL-VS-HA-TR-2004-1001.

2. SAMM2: http://www.kirtland.af.mil/library/factsheets/factsheet.asp?id=7924

3. MOSART/TERTEM: http://www.kirtland.af.mil/library/factsheets/factsheet.asp?id=7916

4. GENESSIS: Shanks, J.G., Shetler, B.V., Heising, S.J., and Blumberg, W.A.M., "Assessment of Spectral-Spatial Information Content Using CLDSIM/GENESSIS/MOSART and Optimal Filters", Proc. of BACIMO'98, AFRL/Hanscom, Dec. 1998.

5. Blumberg, W, Shanks, J., Waugh, F., Dudkin, A., “Comparison of the CLDSIM Cloud Radiance Model with MAMS Imagery from CAMEX-III,” Eos Trans. AGU, 81 (48), Fall Meet. Suppl., 2000, Fall Meeting 2000.

6. Thornburg, R., DeVore, J., Thompson, J., “Review of the CLDSIM Cloud Radiance Simulator,” PR-TR-93-2232, 15 December 1993.

7. Crow, Dennis; Coker, Charles; Keen, Wayne, Fast line-of-sight imagery for target and exhaust-plume signatures (FLITES) scene generation program, Technologies for Synthetic Environments: Hardware-in-the-Loop Testing XI. Edited by Murrer, Robert Lee, Jr.. Proceedings of the SPIE, Volume 6208-18, pp. 62080J (2006).

8. Synthetic Scene Generation Model (SSGM): http://vader.nrl.navy.mil

KEYWORDS: radiance transport, terrain models, cloud models, infrared, surveillance, missile warning

MDA08-033 TITLE: <u>Exploitation of Alternative Wavelengths for Propulsion Related Signature Events</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace, Space Platforms

ACQUISITION PROGRAM: SS, KI, SN, GM, DE, AB, KV

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OBJECTIVE: The objective of this effort is to innovatively extend the capabilities of existing propulsion related signature tools to characterize emission phenomena over a broad portion of the electromagnetic spectrum, from ultraviolet (UV) through the long wave infrared (LWIR). This emission phenomena include all electro-optical (EO) features that may be observed passively through the entire missile flight envelope, from launch through boost phase to impact, that are generated from associated propulsion subsystems or other related phenomenology.

DESCRIPTION: For the last several decades, the propulsion related signature models (encompassing the current plume models) have been primarily focused on characterizing exhaust plume phenomena observed in the short-wave (SWIR) through mid-wave infrared (MWIR) portions of the electromagnetic spectrum (2.5 – 5.0 μm). Several current or advanced sensor concepts within the Ballistic Missile Defense System (BMDS) architecture are considering passive exploitation of signature features within alternative EO band regions that fall outside of that narrow window. The general suite of propulsion related signature modeling tools (which include 2-D/3-D computational fluid dynamic (CFD) codes, Direct Simulation Monte Carlo (DSMC) models and radiation transport (RT) solvers) provide the basic framework for flowfield and signature generation, but do not contain the underlying chemical and physical mechanisms and processes to properly account for these alternative spectral band processes. This deficiency of the supporting databases is that the driving phenomena in these band regions (i.e. particle optical properties, molecular band model parameters, molecular collision cross-sections, and quenching/excitation mechanism pathways) are not well established or characterized. Passive signatures in these alternative wavebands have been demonstrated in data collections from many MDA flight tests as well as other past DoD-sponsored missions, but the ability to model these observations is lagging and as such interested BMDS elements cannot perform or test system concepts and algorithms in these spectral regions. While not comprehensive, the list of relevant propulsion events to be examined in these alternative bands includes: boost phase plumes for all types of propellant systems; propellant fuel and oxidizer venting; particle trails; and solid rocket motor chuffing. Event observables include molecular emission and particle emission and scattering.

PHASE I: For one propulsion related signature event observable of interest, identify the chemical and physical phenomena required to model and properly account for the complete process (from propellant combustion through signature emission) and prioritize the importance of each component as a function of altitude, velocity, and spectral band. Finally, select one important complex component and demonstrate an innovative methodology (theoretical or experimental) to solve for that component unknown. If possible, demonstrate this complex component upgrade within the existing MDA/DESH propulsion related signature tools. Maximum practical use of the existing MDA/DESH propulsion related flowfield and signature framework is desired to reduce both development and validation costs.

PHASE II: Identify additional signature processes and other pertinent phenomenology required to model propulsion-related signatures in the alternative bands. Demonstrate these new or updated code modules, chemical reaction and/or physical process databases within the existing suite of MDA/DESH propulsion related signature models. Further, maximum practical use of available plume software is desired to reduce both development and validation costs. Deliver all demonstrations, upgraded software modules/databases, technical documentation and validation to MDA for independent test and evaluation.

PHASE III: Transition advanced methodology into existing signature models used to support MDA elements. Apply software to a variety of BMDS sensor and missile interceptor systems as well as other problems of interest to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Updated and improved plume flowfield and signature models for a broader portion of the electromagnetic spectrum allows greater flexibility to rocket propulsion companies to utilize passive signature phenomena as a non-intrusive diagnostic tool during subsystem development and testing, such as for vehicle performance metrics, combustion efficiency, vehicle health monitoring, or environmental contamination. In addition, this technology can apply to commercial satellite companies looking at plume contamination as well as space situational awareness characterization.

REFERENCES:
1. Simmons, F.S., Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000.

2. G. Sutton and O. Biblarz. Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.

3. Gimelshein, SF, et al. "Modeling of Ultraviolet Radiation in Steady and Transient High-Altitude Plume Flows", Journal of Thermophysics and Heat Transfer, Vol. 16, No. 1, Jan – Mar 2002, pp. 58-67.

4. Tagirov, VR, et al. "Atmospheric Optical Phenomena Caused by Powerful Rocket Launches", Journal of Spacecraft and Rockets, Vol. 37, No. 6, Nov – Dec 2000, pp. 812-821.

5. Kolb, CE, et al. "Scattered Visible and Ultraviolet Solar Radiation from Condensed Attitude Control Plumes", Journal of Spacecraft and Rockets, Vol. 20, No. 4, Jul – Aug 1983, pp. 383-389.

6. N. Gimelshein, et al. "Numerical prediction of UV radiation from two-phase plumes at high altitudes", AIAA Paper 2007-0114, AIAA 45th Aerospace Sciences Meeting and Exhibit, Reno, NV, 8 – 11 Jan 2007.

KEYWORDS: plumes; boost phase signatures; high altitude; ultraviolet; visible; near-infrared; long-wave infrared; CFD; DSMC; particle optical properties; kinetic rates; collisional cross sections; two-phase flow; reacting flow.

MDA08-034 TITLE: Enhancements to Continuum Plume Flowfield Models for Transitional Flow Simulations

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace, Space Platforms

ACQUISITION PROGRAM: SS, KI, SN, GM, DE, AB, KV

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OBJECTIVE: Numerical models for predicting plume flowfield and signature properties form the basis for development and testing of sensor algorithms related to missile defense applications. For high thrust (> 30,000 lbf) boosting systems operating between altitudes of 100 – 200 km, the methods used for lower altitude (continuum) regimes are no longer physically accurate while the predictive tools for higher altitude (rarefied) regimes, such as Direct Simulation Monte Carlo (DSMC), are too expensive computationally to efficiently treat the entire problem. The objective of this effort is investigate innovative methods to extend the capabilities of continuum plume codes to predict the near-transitional flow regime with increased fidelity as well as greater computational efficiency, stability, and robustness.

DESCRIPTION: Recent MDA sponsored modeling efforts have focused on upgrading plume flowfield and signature predictive tools to operate seamlessly from sea-level to near space conditions. Codes designed for usage in these lower altitude regimes (0 – 100 km) utilized computational fluid dynamic (CFD) methods that offered significant improvement in accuracy over legacy engineering models with a modest increase in computational effort, made possible by taking advantage of multiple CPU configurations, advanced algorithm development and smart flowfield initialization practices.

This effort will concentrate on improving the predictive capability in the near-transitional flow regime, which for high thrust boosting systems (> 30,000 lbf) spans from 100 – 200 km. Over this regime, the governing assumptions for the equations that drive continuum-based methods begin to lose validity. However, the molecular methods geared for rarefied gas environments, while applicable, may potentially require extensive computational gridding constraints such as to make a full simulation numerically intractable. The goal herein is to extend the computational capability of CFD methods beyond the classical continuum breakdown thresholds while limiting degradation to the overall accuracy. This may entail, but is not limited to: updating species diffusion models to incorporate high altitude expansion phenomenon present in low density ambient environments; limiting shear layer growth to contain radial diffusion of the plume – atmosphere interaction; expanding shock diffusion growth models to expand body –

freestream interactions; including high altitude slip boundary conditions to model wall – boundary layer interactions; incorporating non-local thermal equilibrium chemistry capabilities; and improving algorithm efficiency, stability, and robustness to function at very low ambient pressures (less than 1 mPa).

PHASE I: Continuum models should demonstrate the capability to simulate the exhaust plume flowfield and IR signature at 150 km for at least two high thrust boosting systems (30,000 – 200,000 lbf), one of which uses an aluminized solid propellant. Further, identification of techniques for both diffusing species into low density environments as well as incorporation of non-local thermal equilibrium chemistry will be required. A detailed investigation should also be conducted to determine the state-of-the-art in physical models, specifically focusing on accurately solving near-transitional flows with continuum based methods. Encouragement is given to expand literature searches outside standard plume phenomenology databases to find potential methods demonstrated in other disciplines that can be utilized for plume flowfields.

Maximum practical use of existing, plume software for continuum flow regimes is desired to reduce development and validation costs.

PHASE II: Select the most mature physical models identified in Phase I and modify them as necessary for application to plume flowfield simulations. Implement these high altitude physics models and improved algorithm techniques into the existing continuum codes. Criteria should also be established that identifies under what conditions these approaches are acceptable. Demonstrate these “extended-continuum” models for the two boosting systems from Phase I in 10 km increments for altitudes between 100 – 200 km, as applicable. Deliver the technical and software user documentation, software, model demonstrations and validation for MDA use.

PHASE III: Demonstrate seamless integration of updated continuum models for a variety of boosting systems over a large range of altitudes (1 – 200 km). Plume IR signatures shall be generated utilizing FLITES.

PRIVATE SECTOR COMMERCIAL POTENTIAL: : “Extended-Continuum” flowfield modeling may be used by rocket engine developers to both simulate performance metrics and to evaluate induced thermal loads on boost vehicle designs in sub-orbital environments. Similar utility may also extend to those who develop and test smaller thrust propulsion systems, such as for station-keeping and orbital transfer missions on satellites.

REFERENCES:
1. Simmons, F.S. Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000.

2. G. Sutton and O. Biblarz. Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.

3. Wang, W-L and Boyd, ID. "Continuum Breakdown in Hypersonic Viscous Flows", AIAA Paper 2002-0651, AIAA 40th Aerospace Sciences Meeting and Exhibit, Reno, NV, 14-17 Jan 2002.

4. Papp, JL, Yellin, KA and Dash, SM. “Plume and Divert Jet Effects on Missile Flowfields at Higher Altitudes”, AIAA Paper 2004-1110, AIAA 42nd Aerospace Sciences Meeting and Exhibit, Reno, NV, 5-8 Jan 2004.

5. N. Gimelshein, et al. “Numerical prediction of UV radiation from two-phase plumes at high altitudes”, AIAA Paper 2007-0114, AIAA 45th Aerospace Sciences Meeting and Exhibit, Reno, NV, 8-11 Jan 2007.

6. Crow, D., C. Coker, B. Smith, and W. Keen, “Fast Line-of-sight Imagery for Target and Exhaust-plume Signatures (FLITES) Scene Generation Program”, SPIE Defense and Security Symposium 2006, Technologies for Synthetic Environments, Hardware-in-the-Loop Testing XI, April 2006.

KEYWORDS: transitional flow; plumes; boost phase signatures; high altitude; high thrust engines; CFD; continuum breakdown; bow shock; two-phase flow; reacting flow; non-local thermal equilibrium.

MDA08-035 TITLE: <u>Signature Prediction and Uncertainty Analysis for Radar-based MDA</u>

Applications

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: DE

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OBJECTIVE: Develop physics-based radar signature prediction methods and uncertainty analysis techniques for MDA objects of interest.

DESCRIPTION: Resources for defending against a missile threat can be significantly reduced if actual threats can be separated from countermeasures. Radar based automatic object recognition (AOR) has potential as an all-weather technique for identifying MDA objects of interest (MOIs). AOR methods typically use databases of signatures to compare to incoming data for object recognition. Computational electromagnetics (CEM) codes can be used to compute the radar signatures of MOIs. Although asymptotic methods have been used in the past, these methods are approximate solutions. Additional capability is needed to predict higher-order effects like traveling waves. Full-wave solvers (e.g., the method of moments or the finite element method), whether time domain or time harmonic, can be used to provide more accurate solutions. However, these traditional methods are computationally expensive.

Prediction methods must also address geometric and material modeling uncertainty caused by the manufacturing of the object, any modifications made to the object, object changes caused by the environment encountered in a missile defense scenario, or the lack of knowledge about the object. The radar signature effects of MOI uncertainties can be addressed by the Monte Carlo method, but this method is computationally cost prohibitive.

This topic solicits algorithmic advancements for novel CEM predictions for MDA objects of interest. Radar signature prediction methods that increase the efficiency of the computations and retain accuracy for computing the signatures of MOIs (regardless of the phase of flight) are needed. Traceable solution methods that allow the predicted signature to be mapped back to the geometric and material representation of the object are also needed. Hybrid techniques that accurately and efficiently combine one or more methods have potential application Additional research is needed to develop innovative methods for efficient prediction of effects of geometric and material modeling uncertainties on signatures.

PHASE I: Develop a novel physics-based CEM algorithm for predicting the electromagnetic scattering from MOI with a proof of concept of a method for including object variability and uncertainty in radar signature predictions. Plots or tables of the accuracy and compute time showing improvement over standard methods (e.g., the method of moments, implemented with the multi-level fast multipole algorithm.

PHASE II: Physics-based CEM method for predicting the electromagnetic scattering from MOI that efficiently models object variability and uncertainty. Possible further improvement over Phase I results demonstrated by similar plots or tables of accuracy and compute time.

PHASE III: Transition to the MDA community and use of the developed code by MDA and its contractors to compute radar signatures for MDA applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Efficient radar signature prediction methods for complex objects have DoD commercialization potential for object design and development and recognition and fusion algorithm development. With the ability to compute the scattering from cracks and gaps on large objects, this capability could be used to test non-destructive evaluation scenarios in the commercial sector.

REFERENCES:

1. Jin, J.M., Ni, S.S., Lee, S.W., "Hybridization of SBR and FEM for Scattering by Large Bodies with Cracks and Cavities," IEEE Transactions on Antennas and Propagation, Vol. 43, No. 10, October 1995, pp. 1130-1139.

2. Kwon, D.H., Burkholder, R.J., Pathak, P.H., "Efficient Method of Moments Formulation for Large PEC Scattering Problems using Asymptotic Phasefront Extraction (APE)," IEEE Transactions on Antennas and Propagation, Vol. 49, No., 4, April 2001, pp. 583-591.

3. Chauviere, C., Hesthaven, J.S., Wilcox, L.C., "Efficient Computation of RCS from Scatterers of Uncertain Shapes," IEEE Transactions on Antennas and Propagation, Vol. 55, No. 5, May 2007, pp. 1437-1448.

KEYWORDS: computational electromagnetics, CEM, uncertainty, variability, hybrid methods, asymptotic methods, radar

MDA08-036 TITLE: Ballistic Missile Defense System-Level Simulation Optimization

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DE

OBJECTIVE: Design and build software providing an efficient and effective capability to integrate with and control existing medium-to-high resolution, dynamic Ballistic Missile Defense System-level (BMDS-level) simulations to determine optimum parameters of offensive scenario design, BMDS architecture design and/or Warfighter's operational decisions.

DESCRIPTION: As a complex "system-of-systems," the BMDS poses extremely difficult decision problems to both Warfighters and designers. As the diversity and deployed numbers of BMDS elements increases, possible interactions both among elements, as well as between elements and threats, increase geometrically, if not exponentially. Expected sharp increases in the capabilities, numbers, diversities, behaviors and launch areas of both ballistic and air-breathing threats further compound the growth of interactions. The explosive growth of System-level interactions creates a potential in the BMDS for unexpected emergent behaviors, some of which may be highly desirable, while some may seriously impair the performance of the entire system.

Modeling and Simulation (M&S) are key capabilities to fulfilling needs for BMDS testing, performance assessment, training, wargames, exercises, planning and system engineering. However, the growth of potential System-level interactions in the BMDS is rapidly creating a decision space too large for the effective, efficient use of conventional M&S. For example, the Warfighter uses M&S in wargaming to develop new Concepts of Operations (CONOPS) and complementary Tactics, Techniques and Procedures (TTPs) with respect to future threats and BMDS architectures and capabilities. To ensure the development of robust CONOPS and TTPs providing the best BMDS performance across the entire envelope of potential threat laydown and tactics, the Warfighter requires threat scenarios spanning the full spectrum of adversary capabilities and tactics. Use of these full-spectrum threat scenarios helps to ensure that the Warfighter will formulate CONOPS and TTPs with which the BMDS will perform well irrespective of the adversary's tactics. In a large, integrated air-missile defense (IAMD), combined regional-strategic campaign with 102-103 order-of-magnitude threats, the specification of the most reasonably stressing threat scenarios poses an extremely difficult optimization problem: "For a given BMDS architecture and adversary inventories, what are the best threat launch-aim point pairings and tactics to maximize an adversary's Measure(s) of Effectiveness (MOE) from a raid scenario?" The answer to this optimization problem provides a stressing threat scenario against which the Warfighter can evaluate proposed CONOPS and TTPs. In this example, a BMD System-level simulation is implicitly a set of constraints on how well an adversary's threat scenario can inflict damage on Blue targets defended by the BMDS.

Related optimization problems exist in systems engineering and testing of the BMDS. In every case, the optimization problem requires the choice among a relatively large number (perhaps 102-103) of Blue decision variables (e.g., sensor placement, search plans, weapon allocation, defended area assignments) constrained by both explicit conditions (e.g., interceptor inventory, a given adversary scenario) and by implicit performance capability represented by a BMD System-level simulation. Of course, Blue and Red BMD optimization problems involve different MOEs. Thus, for a variety of purposes outlined above, MDA requires a capability to optimize decisions over a BMD System-level simulation with respect to either Red or Blue perspectives.

The past decade has yielded significant progress in simulation optimization (reference 1). The first simulation optimization approaches adapted classical statistical techniques of ranking, design-of-experiments and gradient response surface methodology (reference 2). As these methods can be effective over only a small decision space and a continuous objective function (e.g., MOE), such classical statistical techniques, even with required adaptations for M&S, are unlikely to be effective for BMD System-level simulation optimization with 102-103 decision variables and additional explicit constraints (such as interceptor inventories, range constraints). Additionally, BMDS MOEs and subordinate objectives or goals may be "ill-behaved" functions with discontinuities, some discrete variables and other nonconvexities. Stochastic or "Monte Carlo" modeling within a simulation also introduce mathematical nonconvexities with respect to decision variables (e.g., how sensor search plan decisions eventually affect detection probabilities through simulated interaction of the sensor and a flying threat cloud). Global optimization over a simulation typically requires a combination of a local optimum search with global "de-trapping" from a local optimum to ensure discovery of a true global optimum. Recent simulation optimization approaches have thus included random search, sample path optimization, simulated annealing, genetic algorithms, tabu search, scatter search and neural networks (reference 1). On classical algebraic optimization problems (e.g., traveling salesman), some of these methods have been effective on 103-106 decision variables, but the scientific and mathematical literature do not report simulation optimizations addressing problems in the BMDS scale of interest. Additional potential approaches to the BMDS simulation optimization problem may exist in Artificial Intelligence or other metaheuristics (reference 3).

MDA desires innovative or creative approaches to a BMD System-level simulation optimization capability. The envisioned efforts involve Applied Research into BMDS simulation optimization followed by Advanced Technology Development of an effective, efficient BMDS simulation optimization capability. The capability must accommodate both deterministic and stochastic ("Monte Carlo") BMDS simulations with optimization over 104 order-of-magnitude continuous, discrete or both types of decision variables. The capability must optimize MOE and explicit constraint functions that may be discontinuous and otherwise nonconvex. The capability must also involve a software/systems engineering approach to integrate readily with existing BMDS simulations. Finally, the BMDS simulation optimization capability must exhibit runtime performance compatible with MDA analysis processes (reasonably a few hours).

PHASE I: Develop and demonstrate "proof-of-concept" of an overall BMDS simulation optimization capability approach that includes algorithm(s), supporting rationale/mathematical analysis, system/software integration concept.

PHASE II: Develop and demonstrate an operational prototype of a BMDS simulation optimization in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III: This simulation optimization capability has broad potential for use in a wide variety of military "system-of-systems" applications in terrestrial, marine, air and space mission spaces. Such military applications have similar features of large Blue and Red decision spaces; mathematically complex MOEs and explicit constraints; both deterministic and stochastic analyses; and need for global optimization. Cyberwarfare also presents similar needs for simulation optimization over complex net-centric architectures.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Additional commercial applications with large decision spaces include optimal design and operation of information networks with complex, dynamically adaptive architectures that degrade gracefully under heavy loading or failure.

REFERENCES:
1. Fu, Michael C., Fred Glover, Jay April, 2005, "Simulation Optimization: A Review, New Developments, and Applications," Winter Simulation Conference, Society for Computer Simulation, http://www.informs-sim.org/wsc05papers/010.pdf.

2. Law, Averill, 2006, Simulation Modeling and Analysis with Expertfit Software, McGraw-Hill, New York, 768 p.

3. Siarry, Patrick, Zbigniew Michalewicz (eds.), 2007, “Advances in Metaheuristics for Hard Optimization,” Springer-Verlag, 481 p.

4. Additional information from TPOC in response to FAQs for Topic MDA08-036.
(Includes 10 sets of Q&A.)

KEYWORDS: Ballistic missile defense, simulation, optimization, modeling, systems engineering, software engineering, cyberwarfare

MDA08-037 TITLE: End-to-End BMDS Interceptor / Ground Terminal Communication Links

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: GM, MKV, KI, DV

OBJECTIVE: Develop innovative design/development/test concepts to enhance the reliability of communications between the Ballistic Missile Defense System (BMDS) Fire Control and Interceptor/Kill Vehicles under severe wartime conditions. The focus is to increase probability of message delivery in the presence of both adversarial electronic counter-measures (ECM) and signal fading caused by ionospheric scintillation arising from high altitude nuclear explosions. Provide analysis of proposed communications solutions within the framework of the Missile Defense Agency (MDA) layered architecture, and develop prototype hardware that will demonstrate the utility of the proposed solution.

DESCRIPTION: MDA is seeking innovative approaches to hardening communications systems for current and future Interceptor/Kill Vehicle systems. All future MDA interceptor communication systems must employ effective means to mitigate link performance degradations mechanisms associated with wartime environments. Specific issues that the successful bidder should consider include:
1. Representation and modeling of fading channels and threat ECM techniques.
2. Link Attributes (i.e., data rate, bandwidth, range, latency, error rates).
3. Channel waveform design.
4. Communication system performance prediction methods.
5. Receiver mitigation techniques for signal fading.
6. Jam and Intelligence gathering resistance.
7. Interference avoidance with and from the existing communications systems.
8. Transmission during ground and range testing as well as during wartime operations.
9. Platform weight, size, and power constraints (especially on flight vehicles).
10. New technology insertion alternatives and schedules.
11. Cost trades of proposed communications solutions.

Any proposed communications schemes must be scaleable as Missile Defense architectures grow in both geographic coverage (locations & platforms) and in hardware (number and type of interceptors or kill vehicles).

PHASE I: Contractors shall propose and analyze candidate end-to-end communications solutions for providing robust connectivity to missiles and/or kill vehicles within the evolving MDA architecture. The contractor shall identify the strengths/weaknesses associated with different solutions/ concepts. The output shall be a set of communications system and hardware trades, which substantiate the proposed solution(s) and provides quantifiable metrics for comparison. Issues associated with the high altitude nuclear explosions and insertion of new technologies shall be highlighted.

PHASE II: The contractor shall select the optimal communication system design proposed in Phase I and perform a detailed design of the system. Specific hardware components will be identified and new designs initiated if necessary. New technologies will be developed and demonstrated for hardness, reliability and performance. Contractor shall begin coordination with MDA contractors to ensure products will be relevant to ongoing and planned projects.

PHASE III: The contractor shall work with MDA industrial partner(s) to maximize the transfer of this development to missile defense and to identify a tractable Phase III project that can become a by-product of this overall program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Other efforts within the DoD are focused on two-way data links to weapons systems and this technology will, most likely, be transferred to those programs. The number of weapons that could ultimately use this technology would be substantial. Commercial applications would be in the cell-phone industry, airline communications, and over-the-air communications.

REFERENCES:
1. Digital Communications in Fading Channels: Modulation and Coding, R. L. Bogusch. Mission Research Corp., Report for Air Force Weapons Lab, Kirtland Air Force Base, NM, 1989.

2. DARPA Tactical Targeting and Network Technology (TTNT) program
http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9.

3. Valenti, M.C., E. Hueffmeirer, R.L. Bogusch and J. Fryer, “Towards the capacity of noncoherent orthogonal modulation: BICM-ID for turbo coded NFSK, Proceedings of the IEEE Military Communication Conference (MILCOM), November 2004, pp. 1549-1555.

4. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.

5. For more on high-altitude EMPs, see "U.S. Representative Roscoe Bartlett (R-MD) Holds Hearing on Electromagnetic Pulse and Business," House Small Business Committee Subcommittee on Government Programs and Oversight, FDCH Political Transcripts, Federal Document Clearing House, Inc., June 1, 1999; "U.S. Representative Curt Weldon (R-PA) Holds Hearing on Effect of Electromagnetic Pulse Attacks," House Armed Services Committee Subcommittee on Military Research and Development, FDCH Political Transcripts, October 7, 1999; "Hearing of the Military Research and Development Subcommittee of the House National Security Committee on Electromagnetic Pulse Threats," Federal News Service, Federal Information Systems Corporation, July 16, 1997; and Office of Technology Assessment, "The Effects of Nuclear War," May 1979.

6. Professor David Jenn, “ATMOSPHERIC NUCLEAR EFFECTS”, Naval Postgraduate School, Monterey, CA.

KEYWORDS: communications architecture, jamming, high altitude nuclear explosions, RF data link, fading channels, end to end communications.

MDA08-038 TITLE: <u>Global Missile Defense Battle Management</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BC, SN, GM, TH, AB

OBJECTIVE: This SBIR seeks to advance Information Systems Technology by developing innovative, robust, real-time battle management algorithms and software to support layered missile defense across the theater, regional, and global levels. Battle management solutions must be developed in coordination with multiple dispersed and disparate weapon platforms that are networked together, but still retain control and responsibility for their own individual fire-control systems and endgames.

DESCRIPTION: With the addition of emerging weapon systems, to include boost intercept capability (airborne laser or kinetic interceptor), upgraded SM-3 missiles, kill vehicle systems, and terminal defense systems, the Ballistic Missile Defense System (BMDS) will have the capability for layered defense against enemy ballistic missiles in all phases of flight to defend the United States homeland, forces abroad, and allies and friends. Individually, each of these emerging weapon systems will have robust fire-control systems, but they must be effectively networked together for layered defense by a battle manager that 1) optimizes weapon platform inventories from a global perspective across the entire spectrum of resources ranging from theater to strategic, or 2) maximizes probability of engagement success. Global optimization of weapon platform inventories requires the global battle manager to have knowledge of each weapon platform's inventory and health & status. The pairing assignment and weapon allocation problem will require advanced optimization or assignment techniques. Proposed solutions must demonstrate both a centralized or distributed architecture to support any evolving concept of operations.

Given the robust capabilities of individual weapon systems, the global battle management problem becomes one of allocation, optimization, and adaptive scheduling on several interacting levels.

The first level of allocation is performed by the global battle manager through an assignment that assigns weapon platforms that have access to threat launch events. The global battle manager estimates what the weapon platform's allocation of weapons would be if assigned to a specific threat launch event by taking into account perceived threat inventories and assets being attacked as well as weapon platform capabilities, inventories and commander's intent (i.e., pre-planned options). If more than one weapon platform has threat access, the course of action that optimizes the probability of engagement success is chosen. A second level of allocation at the weapon level is performed by the weapon platform with its higher fidelity models as part of its firing solution. The global battle manager's estimation of feasibility of the pairing and allocation of weapons (a first order approximation) must be compared with the weapon platform's determination of weapon allocation and pairing feasibility through coordination. In this sense the weapon platform – threat launch event pairings are shared responsibilities. If the weapon platform cannot or will not accept an assignment, this is communicated to the global battle manager and the global battle manager will calculate another alternate pairing as the next best course of action that maximizes the probability of engagement success and optimizes weapon platform inventories..

As additional threat information becomes available from sensors, for example, discrimination information revealing additional or different targets, pairing assignments could change requiring adaptive scheduling. Fire control and associated endgames are distributed responsibilities retained by each respective weapon platform.

PHASE I: Identify variables within the assignment-allocation trade space such as inventory, Probability of Engagement Success, and others that are applicable to the engagement planning algorithm. Develop the mathematical basis for and provide a demonstration of advanced allocation methods that will enable robust engagement planning for various weapon systems with different capabilities. Guidance will be provided on representative scenarios for concept evaluation. Concepts can be demonstrated on related problems of commensurate difficulty.

PHASE II: Develop/update the technology based on Phase I to provide a demonstration of the technology in a realistic environment using realistic data, to include realistic processing speeds in complex scenarios and alternate courses of action based on weapon platform coordination.

PHASE III: Integrate the technology into the BMDS in coordination with appropriate BMDS System Engineering and Element Program Offices. Partnership with DoD prime contractors will be pursued as government applications will receive immediate benefit.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This Information Systems Technology is applicable to any allocation/optimization application that operates on components of differing capabilities.

REFERENCES:
1. Hosein P. and Athans, M., The Dynamic Weapon-Target Assignment Problem, Proceedings 1989 Symposium on Command and Control Research, Washington D.C., June 1989.

2. Bertsekas, D.P., Dynamic Programming and Optimal Control, Athena Scientific, Belmont MA, 2001.

KEYWORDS: Optimization, assignment, allocation, adaptive scheduling, engagement planning, Ballistic Missile Defense System (BMDS)

MDA08-039 TITLE: Discrimination

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: BC

OBJECTIVE: This topic seeks to apply innovative techniques in the area of object discrimination through the development of robust algorithms, software, and/or hardware necessary to successfully identify a lethal object from non-lethals in a ballistic missile launch complex. Areas of exploration include algorithms, models, system-level versus sensor-level approaches, dealing with ambiguity, and integration with existing track correlation mechanisms. Solutions must be capable of accurately and reliably supporting acquisition, track, discrimination, and engagement of threatening objects across a spectrum of threat classes and environments.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other types of sensors. It has been shown that when a lethal can be indentified, the system is effective at negating this threat. The challenge today is developing the algorithms that will increase the accuracy in identifying the lethal objects from non-lethal objects in a complex and challenging environment. For example, very highly velocity closely spaced objects in the presence of debris and counter measures makes this a very difficult problem. Improvements currently proposed include the use of attributes as well as metrics information in order to ultimately use discrimination data in handover tracking and correlation. Innovative techniques should provide enhanced battlespace awareness. Fusion of data at several hierarchical levels may be required.

Technical issues that must be addressed include: sufficiently accounting for uncertainty in both threat evolution and sensor feature measurements, over-reliance on a priori information, spatial and temporal registration of radars, data throughput within and between sensor platforms, processing speed and capacity, data latency and gap handling, target feature exploitation, and sensor calibration, counter measure identification and negation, and advanced models.

PHASE I: Develop and conduct proof-of-principle demonstrations of discrimination concepts/methods for the representation of sensor attributes and capabilities that are easily adaptable to a wide range of sensors using simulated sensor data.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment using data from multiple sensors (as applicable) assets sources. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into BMDS system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued as government applications of this technology will produce near term benefits from a successful program.

Develop enhanced Physics-based feature-extraction algorithm to identify characteristics of objects, e.g. Size, Shape, Material properties, thermodynamics, etc. Discrimination of threat/non-threat objects remains important for the BMDS. New ideas for features that can help discriminate objects are needed. This task seeks to develop more accurate feature extraction algorithms based on measurable physical properties that can be used for lethal object discrimination.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to air traffic control, weather radar applications areas of transportation and shipping, e-commerce and robotics industries.

REFERENCES:
1. R. Duda, P. Hart, and D. Stork, “Pattern Classification”, 2nd Ed., Wiley Interscience, November, 2000.

2. Jenson, Finn V. Bayesian Networks and Decision Graphs. New York: Springer, 2001.

3. Gilks, W.R., Richardson, S. and Speigelhalter, D.J. Markov Chain Monte Carlo In Practive. Boca Raton: Chapman & Hall, 1996.

4. Neapolitan, Richard E. Learning Bayesian Networks. Upper Saddle River: Prentice Hall, 2004.

5. Martinez, David, et.al., “Wideband Networked Sensors”, MIT Lincoln Labs, http://www.fas.org/spp/military/program/track/martinez.pdf, October 2000.

6. D. Hall and James Llinas, “An Introduction to Multisensor Data Fusion,” Proceedings of the IEEE, 85 (No. 1) 1997.

7. D.C. Cowley and B. Shafai, “Registration in Multi-Sensor Data Fusion and Tracking,” Proceedings of the American Control Conference, June 1993.

8. Y. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000.

9. T. Sakamoto and T. Sato, “A fast Algorithm of 3-dimensional Imaging for Pulsed Radar Systems,” Proceedings IEEE 2004 Antennas and Propagation Society Symposium, Vol. 2, 20-25 June 2004.

10. W. Streilein, et al. “Fused Multi-Sensor Mining for Feature Foundation Data,” Proceeding of Third International Conference of Information Fusion, Vol. 1, 10-13, July 2000.

11. Mike Botts [ed.], OpenGIS® Sensor Model Language (SensorML), OGC 05-086r2. http://www.opengeospatial.org/standards/requests/31.

12. M. Ceruti, “Ontology for Level-One Sensor Fusion and Knowledge Discovery,” 8th European Conference on Principles and Practice of Knowledge Discovery in Databases, Pisa, Italy, 2004.

13. Steve Havens [ed.], OpenGIS® Transducer Markup Language TransducerML), OGC 06-010r2. http://www.opengeospatial.org/standards/requests/33.

14. Russomanno, D.J.; Kothari, C.; Thomas, O. “Sensor ontologies: from shallow to deep models.” System Theory, 2005. SSST '05. Proceedings of the Thirty-Seventh Southeastern Symposium on, Vol., Iss., 20-22 March 2005. Pages: 107- 112.

KEYWORDS: Inferencing Algorithms, Decision Theory, Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor, 3-D Imaging, Knowledge Representation, Machine-Processable Meaning

MDA08-040 TITLE: <u>Sensor Registration</u>

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BC, DV

OBJECTIVE: Develop advanced, innovative, robust, real-time techniques (algorithms and software) for the real-time monitoring of sensor registration.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) employs multiple sensors, (optical and radar) in the detection, tracking, and identification of ballistic missiles and their constituent pieces. These sensors are geographically dispersed and have differing sensor data capability. These differing sensor data capabilities must be fused together to provide a single integrated operational picture for the warfighter. As the BMDS evolves to incorporate new and enhanced sensors and weapon systems to contend with the increasingly complex ballistic missile threats, the sensor registration capability and control / tasking of these sensor systems will become increasingly complex and difficult, requiring the operators to be supported by innovative sensor registration and sensor planning / scheduling algorithms /tools to provide a single integrated picture of the battle space. The available range of spatially separated EO/IR and radar sensors, each with its own temporally and geometrically constrained view of the battle space, will have increasing demands placed upon them as the need for collection of target tracking and discrimination information expands to cope with countermeasures.

Proposals for the development of innovative sensor registration / management techniques are invited. Sensor registration techniques / algorithms should clearly identify performance improvement for the fused data. Sensor management techniques may be based on dynamic programming or approximations thereto, stochastic programming or otherwise. The proposed sensor management scheme should allow for the need for dynamic reallocation of sensors in response to changing threat priorities and complexity, and arising from changes to sensor availability. Avenues for enhancement should include addressing non-linearity at the edge of a sensor FOV, weather related issues, dynamic atmospheric refractions, utilizing fewer sensor resources to accomplish registration, and tighter coupling between the Sensor Registration capability and the C2BMC algorithms (e.g. track processing).

In proposing schemes, recognition should be made of the following features:
1. Some sensor tasks will benefit from simultaneous observations from different platforms.
2. Depending on the objective, required observations may differ in character from short single looks through frequent revisits to sustained periods of continuous observation.
3. For some sensors, the slew and reacquisition time can be significant and constrain the ability to observe objects with large angular separation.
4. Priorities for sensor tasking must reflect the need to provide fire control solutions for weapon systems appropriate to each layer in the BMDS architecture.
5. The fidelity of track and discrimination information required will vary with time to match key decision points in an engagement.
6. Sensor resources will be required post interceptor launch to support tracking, in flight target update of threat state vectors and discrimination state and provide kill assessment.

Proposed schemes should clearly identify how the performance improvement resulting from extending at any time the algorithm's planning horizon "far sightedness" is achieved at the expense of increased computational complexity to allow trade-offs of performance against processing load.

PHASE I: Develop a mathematical basis for the proposed approach, augmented as appropriate by coding or analysis sufficient to demonstrate it's computational and performance abilities to handle the features 1 – 6 listed above.

PHASE II: Develop / update the technology based on Phase I and provide a demonstration of the technology in a realistic simulation environment, to include using realistic scenarios. Develop an Operational Concept of how the developed solution will be employed by the Warfighter and the elements.

PHASE III: Integrate the algorithm(s) into the MDA Command & Control, Battle Management & Communications (C2BMC) architecture. Partnership with traditional BMDS prime contractors will be pursued as government applications of this technology will produce near term benefits for a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to air traffic control as well as remote sensor and process monitoring applications.

REFERENCES:
1. Kreucher et al. - Efficient Method of non-Myopic Sensor Management for Multi-target tracking. 43rd IEEE Conference on Decision and Control. December 2004.

2. D.P. Bertsekas. - Nonlinear Programming Second Edition. Athena Scientific. 1999.

3. D.A. Castanon. - Approximate Dynamic Programming for Sensor Management. Proceedings of the 36th IEEE Conference on Decision and Control 1997.

KEYWORDS: optimization, sensor management, resource allocation

MDA08-041 TITLE: Power Solutions for Integrated Anti-Tamper Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: AB, AL, BC, GM, KI, DEP, TH, SS, MK, SN, PAC-3

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and implement continuous power enhancements for Anti-Tamper (AT) technology for the protection of critical technology against exploitation.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of Critical Program Information (CPI) from unintentional transfer and the policy for the implementation of AT technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that prevent and/or delay exploitation of critical technologies in U.S. weapons systems. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component.

This topic seeks to improve power solutions for use when providing power for the operation of Anti-Tamper techniques to protect weapon systems. This includes the development of power sources and the innovative implementation of COTS power sources for AT applications. Such measures could increase battery life and enhance integration and operation of protective techniques/technologies.

This effort will focus on developing enhanced power solutions that provide sufficient power to AT techniques and technologies for initiating and accomplishing protective actions. . The power solution(s) need to be independent, small, light weight, and covert to protect from tampering. Attention will be placed on longevity of power source (minimum of 15 years up to 20 years), cost introduced into weapons platforms and their associated hardware and software. Methodologies may include but not limited to; storage, self-powered, energy harvesting. As a result, the MDA will maintain a technological edge in support of the war fighters.

The development and application of power solutions should address 1) significant challenges associated with implementing AT utilizing current available power sources, 2) power integration as a seamless part of AT integration into the weapons system. These power enhancements should increase battery life, decrease technical risk, or decrease cost associated with current methods of AT implementation.

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT power options. The contractor will also perform an analysis and limited bench level testing for an understanding of the power requirements and provide metrics to be used to demonstrate the value of these enhancements.

PHASE II: Demonstrate and validate the use of AT power enhancements via one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Integrate selected AT power enhancements into a critical system technology, for a BMDS system level test-bed. This phase will demonstrate the application to one or more MDA element systems, subsystems, or components and the product's utility against industrial espionage. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to facilitate protection against tampering in a real-world situation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in battery technologies take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense applications. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost or improve the performance of products that utilize innovative power technology.

REFERENCES:
1. Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.

2. Ingle, K. A. Reverse Engineering, McGraw-Hill Professional, 1994.

3. Furber, S., ARM System-on-chip Architecture, Addison-Wesley, 2000.

4. Huang, A. Hacking the Xbox: An Introduction to Reverse Engineering, No Starch, 2003.

KEYWORDS: Anti-Tamper (AT), Electronics, Power, Battery, Reverse Engineering, Exploit

MDA08-042 TITLE: Real-time Application Security in a Communications Network

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: GM, MK, KI, DOSA

OBJECTIVE: Develop and demonstrate innovative solutions to the problem of application security within the context of Ballistic Missile Defense System (BMDS). The suite of software applications within the BMDS are an important target for the enemy. Maintaining the highest levels of application security and information assurance are of utmost importance to the mission.

DESCRIPTION: Security efforts to date have focused primarily on network security vs. software security. Historically, organizations have focused on protecting the perimeter with firewalls and on detecting attacks that have occurred or are underway. Awareness of software security vs. network security issues is gaining momentum, and the new wisdom is for enterprises to test applications for security in addition to functionality, performance and usability prior to deployment. Applications are mission enablers, allowing people and programs to access the data and information they need to perform critical functions. Because that information is often the target of an attacker, applications must be architected based on security requirements as much as they are based on functionality, performance, usability and quality requirements. Programmers are taught to write bug-free code vs. secure code. The realization of the need for secure code development and for security to be a fundamental design requirement has only just begun. , As a result, many of the applications deployed today were created without security requirements. To protect an environment running such software, an organization needs mechanisms that find security flaws in its deployed applications and prevents those flaws from being exploited.

Within the context of a distributed, real-time information assurance management platform, there is a need for a process with the ability to interrogate user applications for security vulnerabilities, monitor them for attack while in operation and track the status of improvements to correct the vulnerabilities.. The topic author is looking for innovative solutions that will automate the latest in application penetration testing within the BMDS. The solution should be able to operate in both a test and operational state. During operational state the goal should be on monitoring for live attack directly on the running software applications. During test state the solution should focus on more indepth application penetration testing. Both solution states should provide as an output recommended code changes.

Innovative solutions should be explored to record and monitor the security level or state of the system at each stage of testing. This will serve as an indicator of the risk reduction per software vulnerability and should integrate into any security accreditation reporting requirements. Towards this end innovative solutions should include but not be limited to:

1. real-time software application penetration testing capability
2. graphical security level state information
3. recommendations for improvements with complexity factor and projected gain as reported by reduced security risk level
4. status of improvements to date

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of methods for real-time application security systems that provide insight into this aspect of the overall comprehensive situational awareness of the Information Assurance state of the BMDS and its components.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates advancement of application security systems by illustrating security status for a subset of BMDS components.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Application Security technology has application throughout commercial industries. Commercial systems that are exposed to internet and corporate intranets would benefit greatly from this development. In addition to military and homeland defense, banking, finance, e-commerce, and medical industries would have a high demand for such systems.

REFERENCES:

1. Shaikh, R.A., Rajput, S., Zaidi, S.M.H., Sharif, K, "Comparative analysis and design philosophy of next generation unified enterprise application security", Emerging Technologies, 2005, Proceedings of the IEEE Symposium, 17-18 Sept. 2005, pp. 517–524.

2. Stytz, M.R, "Considering defense in depth for software applications", Security & Privacy Magazine, IEEE, Jan.-Feb. 2004 Volume: 2, Issue: 1, pp. 72–75.

3. Whittaker, J., "Why secure applications are difficult to write", Security & Privacy Magazine, IEEE, Mar-Apr 2003 Volume: 1, Issue: 2, pp. 81–83.

4. Thompson, H.H., "Application penetration testing", Security & Privacy, IEEE, Jan.-Feb. 2005, Volume: 3, Issue: 1, pp. 66-69.

5. Arkin, B.; Stender, S.; McGraw, G, "Software penetration testing", Security & Privacy, IEEE, Volume 3, Issue 1, Jan.-Feb. 2005, pp. 84–87.

KEYWORDS: application security, network security management, intrusion prevention, cybersecurity

MDA08-043 TITLE: <u>Ballistic Missile Defense Anti-Tamper Penalty and Response Capabilities</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: DEP

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OBJECTIVE: Develop and implement new innovative anti-tamper (AT) response and penalty protection technology for the protection of critical technology against exploitation.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of Critical Program Information (CPI) from unintentional transfer and the policy for the implementation of anti-tamper technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that prevent and/or delay exploitation of critical technologies in U.S. weapons systems. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component.

This topic seeks to identify methods to respond to tamper events that may lead to unauthorized access to CPI. Though the particular solution may be tailored for individual applications, the concept and methodology of the solution should be applicable to various COTS and military hardware. Preference will be given to solutions that provide protection for Critical Technologies without introducing additional risks or costs to the weapon platform and its mission.

This effort will focus on developing innovative AT response techniques and technologies that provide protection from reverse engineering and compromise of CPI. Attention will be placed on safety of the proposed methods, covertness of application, and seamless integration into weapons platforms. As a result, the MDA will maintain a technological edge in support of the war fighters.

Response and penalty methodologies may include, but are not limited to:
• Destruction of CPI
• Surreptitious configuration alteration
• Irreversibly degraded performance
• Commensurate response to match attack

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT protection technology or technique that is integrated with, or tailorable to, the CPI being protected. The contractor will also perform an analysis and limited bench level testing for an understanding of the new and innovative response protection technology.

PHASE II: Demonstrate and validate the use of AT protection technologies into one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Integrate selected AT protection technologies into a critical system technology, for a BMDS system level test-bed. This phase will demonstrate the application to one or more MDA element systems, subsystems, or components and the products utility against industrial espionage. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against tampering in a real-world situation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovative process technology.

REFERENCES:

1. Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.

2. Ingle, K. A. Reverse Engineering, McGraw-Hill Professional, 1994.

3. Furber, S., ARM System-on-chip Architecture, Addison-Wesley, 2000.

4. Huang, A. Hacking the Xbox: An Introduction to Reverse Engineering, No Starch, 2003.

KEYWORDS: Anti-Tamper, Protection, Response, Penalty, Reverse Engineering, Exploit, Electronics

MDA08-044 TITLE: Development of Fast and Slow Cook-off Mitigation Sensor

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: QS

OBJECTIVE: Develop a novel and innovative sensor no more then 2 cubic inches that utilizes the thermal energy of the fast and slow cook off scenarios to produce in excess of 1 amp/1 watt of power to trigger a mil-standard squib which would cause venting or activate a venting system.

DESCRIPTION: Federal law requires all munitions be developed to meet the prevailing requirements for Insensitive Munitions (IM). Currently, to meet the (IM) requirements for fast and slow cook off, venting systems are used to reduce confinement of the energetic materials prior to ignition thus reducing the level of reaction violence. There are two type of venting systems, active and passive. Both use a thermal trigger. Active mitigation uses a powered sensor to determine when to trigger the venting mechanism, usually a liner shape charge. Passive mitigation uses a thermally sensitive material to deform and mechanically vent the case. Both types of mitigation have benefits and drawbacks. Active mitigation, while quickly venting the case, requires a constant power feed to the sensor and additional safety precautions must be taken to mitigate accidental triggering. Passive mitigation requires no external power, and relies on deformation of materials properties producing delayed venting.
The proposed sensor design should combine features of passive and active venting technology. It should only rely on the thermal energy provided by the cook-off scenario. It should also respond quickly, to trigger the venting. It should fail safe to reduce the risk of accidental ignition. The solution must not significantly limit or reduce the functionality and reliability of the system. The proposal technical approach should clearly and specifically outline how the technology will affect and benefit the IM properties of the SRM or system.

PHASE I: Develop a small sensor that can convert the thermal energy of a cook-off scenario into sufficient energy to trigger a mil-standard squib. The squib would then trigger a venting system. The squib should only receive power from the sensor and only when the sensor reaches 275 degrees F and should not fire the squib any time after reaching a temperature of 350 degrees F. To have a successful phase one, it must be demonstrated that the sensor will trigger the squib under these thermal conditions.

PHASE II: Refine the concept to meet the temperature, size/volume and power requirements and integrate the sensor unit into a Thermally Initiated Venting System. Demonstrate technology in an actual cook-off environment using an analog motor.

PHASE III: Continue improving and testing the technology. Work to develop a sensor that can be tuned to meet different motor requirements. Work with industry and government labs to integrate the technology in missile development programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Development of insensitive munitions technology in support of military and commercial research is a rapidly-growing scientific endeavor. The proposed effort would be extremely useful in providing data to ensure the safety of personnel exposed to heat shock and impact in commercial space flight applications and in commercial transportation of energetic components or systems.

REFERENCES:
1. “Department of Defense Acquisition Manager’s Handbook for Insensitive Munitions” Rev 01, January 2004.
2. “Insensitive Munitions Technology for Tactical Rocket Motors” by Andrew Victor 1994.
3. NATO’s Munitions Safety and Information Analysis Center (MSIAC, formerly NIMIC)
4. “US DOD IM Program” by Anthony J. Melita http://ww.dtic.mil/ndia/2003gun/mel.pdf)
5. “US Navy Insensitive Munitions Requirements,” Naval Sea Systems Command, NAVSEAINST 8010.5B, 5 Dec 1989.

KEYWORDS: insensitive munitions, venting, sensors, insensitive solid rocket motor design, missile thermal heating

MDA08-045 TITLE: MIL-STD-1901A Compliant In-Line Initiation Systems for Propulsion Applications

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: QS, AB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this research and development effort is to develop in-line initiation systems for propulsion applications that are fully compliant to all provisions of MIL-STD-1901A and MIL-DTL-23659.

DESCRIPTION: MIL-STD-1901A currently requires that propulsion Ignition Systems utilize energy train and pyrotechnic train interruption devices whose reliability is demonstrated through approved statistical and experimental approaches, unless the following provisions are met:
• The initiator device can only be initiated with an electrical stimulus of greater than 500 V.
• The energetic material contained in the device is equal or less sensitive than Boron Potassium Nitrate (BKNO3).

In a number of MDA controllable propulsion applications, it is not feasible to utilize traditional energy and pyrotechnic train interruption devices (usually known as “out-of-line devices”). These applications include Divert and Attitude Control System (DACS), axial stage Attitude Control System (ACS) and multiple pulse solid rocket propulsion systems. Usually in these applications, multiple ignition events are required on-demand, and it is difficult to package traditional compliant “out-of-line” Arm-Fire Devices (AFD’s) capable of supporting multiple ignition events. There is significant pressure from DoD safety boards to field fully compliant initiation systems for emerging and future MDA propulsion systems. Focused investment on enabling technology is critically needed to accelerate development and insertion of viable 1901A compliant initiation systems into spirally evolving and new-start MDA propulsion systems.

This topic requests proposals that pertain to the development of fully 1901A compliant in-line initiation systems. Desired characteristics include:
• Approach must be fully MIL-STD-1901A compliant without the use of safety augmentation devices, including full compliance to testing and requirements outlined in MIL-DTL-23659. This includes compliance to the Electrical Cook-off Test specified in A.4.10 of MIL-DTL-23659D, with the exception that the selected device must not undergo deformation, rupture or venting that could initiate the next in-line energetic component.
• Approach must be applicable to initiators of multiple sizes and interfaces. A notional minimum size is an initiator of 0.20” diameter x 0.20” long.
• Device must be capable of reliably initiating output charges of different sizes.

• The device must be able to sustain over 3000 psi operating pressure on the output side for over 2 minutes without leaking. Rocket motor chamber temperature varies between 3500 deg F and >6000 deg F, depending upon application.
• Approach should include or be compatible with an electrical fireset capable of converting standard missile 28 V power to high voltage and discharging it with output characteristics required to reliably function the selected initiator. The ability to closely couple the fireset and initiator is desired. The ability to integrate environmental “Safe-ing” and “Arming” features into the fire set is desired.
• Selected electrical fire set and initiation system approaches should be capable of reliably operating in a vacuum environment of 1.4 Torr or less, without generating arcs or discharges.
• Ignition systems that can demonstrate breakdown capability with high statistical reliability and without selective pre-screening of components are preferred. Initiation systems must provide a high degree of protection against function at >500 V. However, all-fire function at <1500 V is preferred.

PHASE I: Conduct studies and component demonstrations necessary to demonstrate that the selected concept can meet full requirements of MIL-STD-1901A and the guidelines outlined above.

PHASE II: Demonstrate the feasibility and engineering scale-up of a fully compliant Ignition System. Demonstrations shall include firing components and prototype ignition systems under representative operating conditions (e.g., vacuum) and with a program representative igniter. Additionally, key critical safety tests outlined in MIL-STD-1901A and MIL-DTL-23659 shall be performed.

PHASE III: Transition the fully compliant in-line initiation system to a MDA program element application via rigorous engineering development and qualification activities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Private sector applications include Launch Vehicles (Propulsion and Separation Ordnance), Safe Demolition Initiators, and Air Bag Initiators.

REFERENCES:
1. MIL-STD-1901A, “Munition Rocket and Missile Motor Ignition System Design, Safety Criteria For”, dated 6 June 2002.

2. MIL-DTL-23659D, “Initiators, Electric, General Design Specification For”, dated 3 March 2003.

KEYWORDS: Arm Fire Device, MIL-STD-1901A, MIL-DTL-23659, In-Line Electrical Initiator, 1901A Compliance

MDA08-046 TITLE: <u>Safety Technologies for Liquid Hypergolic Propulsion Systems</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP, GM, KI, QS, TH, KV

OBJECTIVE: The Missile Defense Agency (MDA) is seeking innovative concepts and products to improve the safety and maintainability of hypergolic propellant based propulsion systems. This includes sensor technology and leak mitigation technologies. The overall goal of projects selected under this topic will be to develop and demonstrate innovative technologies to enable safe storage and deployment of liquid hypergolic propulsion (LHP) system for ballistic missile defense interceptors.

DESCRIPTION: MDA divert and attitude control systems (DACS) are required to achieve accurate intercepts over a long mission time. In order to meet these requirements, response time and long operating time, hypergolic propellants are needed. Hypergolic propellants and oxidizers tend to be corrosive, toxic and present fire hazards in the event of leaks. Given the need to transport systems over road, air and sea, safety technologies need to be incorporated to detect an mitigate the hypergolic hazards.

• Sensor technologies include those sensors that can detect MMH/N2O4 leaks of Interceptor located in side the canister to the levels (Detection levels of less than 100 ppm) the sensor life should be no less than 4 years with no calibration required between replacement. This includes light weight, low consumption batteries to power active sensors or development of passive sensors to operate without a power inputs. These sensors must be able to operate without providing false positive readings.

• Leak mitigation technologies would include self sealing tank material to contain leaks in the event of a tank breach or puncture. Innovative technologies associated with sealing materials that could be used to seal possible leaks in tubing, tanks containing hypergolic propellants and oxidizers that would not hinder performance delivered by the system. Other mitigation technologies could include neutralization of the hypergolic liquids to prevent fire hazards or toxic vapors from causing harm or possible loss of operational capability.

PHASE I: Show understanding of the safety problems with different types of hypergolic systems. Propose technology solutions or system approach solution to improve the safety of LHPs. Design and conduct proof-of-principle demonstrations. Prepare paper outlining the safety benefits and improvements of the technology or system.

PHASE II: Develop a small-scale LHP system or technology demonstration to show its safety ability, considering Navy shipboard applications. Conduct hazard classification and insensitive munitions tests as deemed appropriate. Provide a plan for introducing the proposed LHP system or technology.

PHASE III: Work with industry and government labs to plan the introduction of the technology in energetics development programs. Prepare for release of data to the hypergolic community.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The development of a safer hypergolic system would be extremely useful to ensure the safety of personnel exposed to LHP systems in commercial space applications as well as other commercial industries which employ the use of hypergolic.

REFERENCES:
1. MIL-STD-882D, “Standard Practices for System Safety,” 10 February 2000.

2. “Modern Engineering for Design of Liquid-Propellant Rocket Engines,” Huzel & Huang, pub. AIAA, 1992.

3. “History of Liquid Propellant Rocket Engines,” G. Sutton, pub. AIAA, 2005.

4. “Hazard Assessment Tests for Non-Nuclear Ordnance”, Military Standard, MIL-STD-2105C.

KEYWORDS: Hypergolic fuels, hypergolic liquid propulsion, shipboard safety

MDA08-047 TITLE: Compact High Power Microwave Payloads

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: AL

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OBJECTIVE: Design and build a compact pulsed power devices for High Power Microwave (HPM) Payloads for small rockets and/or the Multiple Kill Vehicles (MKVs), DESCRIPTION: Recent advances in capacitors, explosive pulsed power generators, power conditioning (solid state switching, vector inversion generators), and HPM sources (magnetrons, light weight MILOs) suggest that it may be possible to install these systems into small smart communicating kill vehicles, such as the Multiple Kill Vehicle (MKV), that have a diameter of 3 inches and a length no greater than 24 inches. These compact HPM systems have several applications including directed energy weapons for destroying countermeasure dispensers and guidance and control electronics and for blinding sensors, bistatic radars for discrimination of countermeasures, and sensors for engagement damage assessment. These systems must be compact, lightweight, designed to reduce the introduction of space debris, and capable of surviving high g-force launches and operation in the space environment. One possible scheme would be to use a thermal battery to charge super capacitors that would seed a small flux compression generator (FCG) that drives a HPM tube. At this time, the FCG is the only power supply that is capable of generating very high powers and yet still maintain a very compact form factor. However, FCGs tend to generate debris because they are explosive driven. Therefore, the objective of this effort is to develop innovative FCG designs that can meet the power requirements of the HPM load, maintain their small size, withstand relatively high g-forces, and minimize space debris. These are all very challenging requirements in their own right, but even more challenging when trying to meet them all at the same time, which means that current FCG designs are not satisfactory and new innovative designs are required.

PHASE I: Design an FCG that is capable of driving a HPM load, surviving high g-force launches, and generating minimal debris. As part of Phase I, demonstrations must be performed to verify that the design has the potential capability to meet part or all these requirements with emphasis focused on minimizing debris.

PHASE II: Develop and demonstrate a prototype FCG that is capable of driving an HPM load, maintaining their small size, surviving relatively high g-force launches, and produces minimal debris. As part of this Phase, issues associated with manufacturing these FCGs should also be addressed.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications such as Emergency Ordnance Disposal, vehicle stopping, special operations, propulsion systems, chemical and biological agent decontamination, oil and mineral exploration, and emergency burst communications.

REFERENCES:

1. L. Altgilbers, “Recent Advances in Explosive Pulsed Power”, Journal of Electromagnetic Phenomena, 3(4(12)), pp. 497–520 (2003).

2. R.J. Barker and E. Schamiloglu, High-Power Microwave Sources and Technologies, Wiley-IEEE (2001).

3. J. Benford, J.A. Swegle, and E. Schamiloglu, High Power Microwaves, 2nd Edition, CRC Press (2007).

4. L. Altgilbers, M. Brown, I. Grishnaev, B. Novac, I. Smith, Ya. Tkach, and Yu. Tkach, Magnetocumulative Generators, Springer-Verlag, New York (2000).

5. A. Neuber, Explosively Driven Pulsed Power: Helical Magnetic Flux Compression Generators, Springer, Berlin (2005).

KEYWORDS: Pulsed Power, High Power Microwave, Power Conditioning, Antennas, Switches, Capacitors, Flux compression Generator, Countermeasures, Directed Energy

MDA08-048 TITLE: Improved Pressure Recovery System

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: AL

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OBJECTIVE: Improve the performance, reliability, vibration environment and reduce the overall system weight for the Pressure Recovery System (PRS) used by the Airborne Laser (ABL) Program.

DESCRIPTION: The ABL Chemical Oxygen Iodine Laser (COIL) creates a lasing medium by producing Singlet Delta Oxygen (SDO) mixed with Helium which is then delivered to a plenum/nozzle assembly and injected with a mixture of Iodine and Helium. This reactive mixture passes through converging-diverging nozzles into the laser cavity where it expands to a quite low pressure. To achieve this low pressure the current ABL uses diffuser and steam ejector systems which pump the laser cavity gases overboard at aircraft operational altitudes. A practical balance between the performance of the diffuser and the ejector must be achieved with constraints; however the focus of this effort is the steam ejector system. The overall length of the diffuser-ejector system is constrained by the aircraft dimensions.

ABL is interested in optimization of the current design/configuration, improvements to include methods for real time controlling/varying the mass flow rate of steam, as well as selected innovative excursions including but not limited to approaches that take fuller advantage of the varying pressure distribution along the aircraft body, alternative starting concepts, advantages of starting and operating with a range of higher cavity pressures, improved diffuser performance and reduced vibration environment.

If these results are realized, they would provide significant synergistic benefits to the ABL weapon system to include support for an increased engagement magazine, reduced payload weight resulting in longer time on station and reduced logistical footprint.

Proposal presenters are encouraged to show innovative methods to improve ABL ejector performance, model alternative approaches and reduce the weight of required hardware as well as expendable propellants.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Conduct computer modeling, subscale testing or other verifiable methods to help understand the benefits of innovative concepts identified. Select the most promising approaches that have a clear traceability to the ABL system. Based on your selection criteria, develop multiple Concept Designs for subscale devices and a Phase II Program Plan for the design, fabrication and test (including test reporting) of subscale device(s) to validate the selected concept.

PHASE II: Execute the Program Plan developed in Phase I as directed by the government. In a meeting with the Government, jointly select one or more of the concept designs from Phase I. Design, fabricate, integrate and test the selected concept(s) as specified in the proposed Program Plan. The test report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate clear traceability to a full-scale device. Develop a Phase III Program Plan that will include your integration and test strategy for a module sized full scale ejector device. Identify remaining key technical challenges, risks, and risk mitigation strategies. This plan should include proposals for tests of the full scale device either in-house, or at a contractor or government facility.

PHASE III: Design and build a full scale prototype, with a complete diagnostic suite for measuring its flow properties and pressure recovery in a laboratory environment. Perform flow tests, including start tests, on the prototype to demonstrate its ability to support ABL requirements and provide a detailed evaluation report.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient ejector processes are important for the chemical processing industry (CPI) and power generation plants. Additional potential commercial applications are for processes that require very large, short duration vacuum pumping requirements. Improved COIL processes also stand to benefit the industrial use of high power lasers for welding, cutting, and other material process applications which require lasers with high power output and excellent beam quality.

REFERENCES:

1. Carroll, D.L., King, D.M., Fockler, L., Stromberg, D., Madden, T.J., Solomon, W.C., and Sentman, L.H., “COIL for Industrial Applications,” AIAA-98-2992, p. 1-11 (1998).

2. Manke II, Gerald C. and Hager, Gordon D., “Advanced COIL – physics, chemistry and uses,” Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).

3. Shapiro, Ascher H., The Dynamics and Thermodynamics of Compressible Fluid Flow, The Roland Press, New York, 1953.

4. Liepmann & Roshko, Elements of Gasdynamics, John Wiley & Sons, Inc., New York, 1957.

KEYWORDS: Airborne Laser, Ejector, Steam Ejectors, Pressure Recovery

MDA08-049 TITLE: Advanced Light-Weight Solid State Laser Cooling System (High Power Solid State Laser)

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: AL

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve the efficiency, performance, reliability, maintainability; reduce the vibration environment and overall system weight for the Laser Refrigeration System (LRS) used by the Airborne Laser (ABL) Program.

DESCRIPTION: The ABL has significant cooling requirements that until present can only be addressed by mechanical refrigeration systems. These include cooling of the various high powered solid state lasers currently used on the ABL for tracking and ranging as well as standby cooling for the BHP loops on the Chemical Oxygen Iodine Laser (COIL). The performance goals for this program are stated below.

ABL is interested in pursuing in innovative concepts that improve ABL LRS performance to 100 kW heat rejection at 20 Degrees Celsius, and 15 kW heat rejection at -15 Degrees Celsius as well as intermediate settings. Wall plug efficiency (heat rejected divided by electrical power in) is one of the standards by which proposals will be judged and must be clearly identified. Reliability and maintainability goals are less than one failure requiring shutdown in 8000 hours of continuous operation at heat loads representative of operational scenarios (MTTF) and replacement/refurbishment of affected parts in less than 24 hours (MTTR). The duty cycle for the system should be continuous operation at 15 kW heat rejection with 90 seconds operation at 100 kW every five minutes ten times per 24 hour period. It should be able to cycle from 15 kW to 100 kW operation in less than one second and cycle from a complete shutdown to 15 kW operation in less than 10 seconds. The set point accuracy should be +/- 0.5 Degrees Kelvin. The heat sink for airborne is operations is from a NACA type duct on the aircraft at operational altitudes. The laser cooling fluid must be water with automatic control of biological activity, pH and electrical conductivity. It must utilize cover gases and construction materials that minimize the presence of carbon dioxide in the system. The refrigerant is not specified but if used must be non-toxic and readily available and the offeror must supply an MSDS at the time it is selected. The system should have a very low vibration environment either producing or isolating itself to transmit less than .05 g at frequencies between 20 and 2000 Hertz to its supporting platform. Weight is always an important consideration for airborne platforms. The goal for this program is less than one hundred kilograms for the LRS (including its supporting pallet but not including ancillary plumbing to transport cooling fluids to cooling locations). The eventual system must be fully flight qualified. Examples of innovative features of a design might be but are not limited to: monobloc or integral design for the evaporator, condenser, pump, and compressor; monobloc construction from composite materials with an integral evaporator, condenser, pump, and compressor; tailored material thermal and structural properties for the components; common driver for the pump and compressor; and extended heat-transfer surfaces for the evaporator and condenser.

If these results are realized, they would provide significantly improved performance, reliability and maintainability benefits to the ABL weapon and support a reduced payload weight resulting in longer time on station which together mean a reduced logistical footprint.

Proposal presenters are encouraged to show innovative methods to improve ABL LRS performance and reduce the weight of required hardware. Proposals for accelerated development are encouraged.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Develop computer-based models as necessary to be used to examine alternative designs in terms of their weight, volume, and performance flexibility. Select the most promising approaches that have a clear traceability to the ABL system. Based on modeling results, develop multiple Concept Designs for subscale scale devices (roughly 10 kW maximum heat rejection) and a Phase II Program Plan for the design, fabrication and test (including test reporting) of a single subscale device to validate the selected concept.

PHASE II: Design and build a sub scale prototype as defined in phase I, with a complete diagnostic suite for measuring its performance in a laboratory environment. Perform reliability and maintainability testing, including shutdown and start-up tests, on the prototype to demonstrate its ability to support ABL requirements and provide a detailed evaluation report. Develop a Phase III Program Plan for the design, fabrication and test (including test reporting) of a full scale device.

PHASE III: Design and build a full scale prototype, with a complete diagnostic suite for measuring its performance in a laboratory environment. Perform reliability and maintainability testing, including shutdown and start-up tests, on the prototype to demonstrate its ability to support ABL requirements and provide a detailed evaluation report.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient, reliable and higher performance refrigerators have widespread commercial applications including food preservation as well as air conditioning. Higher efficiency cooling systems are also extremely environmental friendly and even higher costs would not impair their attractiveness to important parts of the market.

REFERENCES:
1. Manke II, Gerald C. and Hager, Gordon D., “Advanced COIL – physics, chemistry and uses,” Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).

2. S.R. Bowman and C.E. Mungan, New materials for optical cooling, Appl. Phys. B 71, 807 (2000).

KEYWORDS: Airborne Laser, High Energy Solid State Lasers, Refrigeration, Reliability, Cooling Systems

MDA08-050 TITLE: <u>Passive Range Estimation from Angle-only Sensor Data (Acq Pointing & Tracking)</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: DV, AL

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OBJECTIVE: Create an integrated capability for range estimation via application of passive angles-only sensor data. Define sensor and processing requirements, simulate physical conditions and data products and design, develop and demonstrate an integral system to estimate range to an accelerating missile or rocket using passive angles-only sensors together with platform data from the host aircraft.

DESCRIPTION: Modern aircraft based sensor suites that are tasked to autonomously detect rockets and missiles have a compelling need to estimate range as part of constructing 3-D state estimates for those objects. Applications which have attempted to estimate 3-D states have historically been limited to those areas where additional a priori constraints are valid (ballistic motion or physical imaging of the object with knowledge of its shape and size). Real rockets and missiles have specific characteristic behaviors that produce radiance that must pass through the atmosphere prior to being sampled by the onboard sensor suite of the aircraft.

Applications that might be considered to provide range estimation include: 1) Parallax techniques that use the physical size of the platform to obtain a direct range estimate from observed angle differences from different points on the aircraft. 2) Boot-strapping techniques that use the observation history (elevation and azimuth) together with models to estimate range histories. 3) Differential absorption techniques to use Beer's law, atmospheric models and insitu data on the local atmospheric conditions to estimate the range to targets. 4) Differential refraction techniques to estimate the range to targets by the spectral dispersion in estimated elevation to the target together with ray-tracing through different atmospheric models. 5) Multiple model techniques that employ various potential models of missile behavior to create modeled measurement histories that can be compared to physical measurements in an inverse modeling approach.

PHASE I: Define a viable strategy to take passive angles-only sensor data to estimate range from a host platform to missiles and rockets. Create a physics based simulation of the technique and evaluate sensitivity and performance for a range of sensor parameters. Create a causal calculation environment that can show the feasibility and computational complexity of the technique leading to the definition of a real-time capable system. The development of novel algorithms and analysis techniques to determine range passive is the end goal.

PHASE II: Develop and demonstrate a prototype system in an airborne environment. Work with MDA test and others to conduct testing and evaluation of the technique in various airborne scenarios of application to missile defense problems.

PHASE III: The system defined and demonstrated has applications to missile-warning applications for civil and military aircraft for MANPADS, and SAMs as well as acquisition pointing and tracking for airborne surveillance platforms supporting missile defense.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The system defined and demonstrated has applications to missile-warning applications for civil and military aircraft for MANPADS, and SAMs as well as acquisition pointing and tracking for airborne surveillance platforms supporting missile defense.

REFERENCES:
1. See the Conference Proceedings on Military Sensing Symposium: Missile Defense – Sensors Environments and Algorithms from 2001 to present under the keywords above.

2. http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA410641

3. http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADD000416

4. http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA136838

KEYWORDS: Monocular Passive Ranging, Parallax, Inverse Methods

MDA08-051 TITLE: Advanced LADAR Modeling

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: DV, AL

OBJECTIVE: To develop and demonstrate new techniques for modeling Ladar at long ranges over a variety of ladar options (coherent vs. direct detection, various wavelengths, et al). A ladar system is a laser radar. This is a combination of a laser transmitter and a receiver of some sort that will allow you to determine a variety of information from the return of the laser. This information could include, time since pulse was sent and power / number of photons received back at the source. In addition there are a number of standard implementations of modern laser radars. It is desired to create algorithms to evaluate implementations of modern ladars.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the current state of the art of long distance Ladar modeling. Physics-based models of laser interactions with boosting missiles at long ranges are needed in support of Air Borne Laser (ABL) SPO selection of an optimal ladar system and future simulation of the weapon system. Modification of currently available ladar codes is acceptable as is the development of a new code.

PHASE I: Development of a model that will allow full simulation of various laser radar systems. Development of algorithms for the incorporation of the long distance requirement. Also the development of the software architecture which should include: current, if any, ladar code that will be used, full range of options to be modeled, and algorithms for new options to be included.

PHASE II: Develop detailed algorithms and implementations. The model may incorporate various design options for Ladars including: coherent vs direct detection, various wavelengths, aperture size, ladar pointing accuracy, system jitter, phase, speckle and detector type. The goal is to be able to simulate a variety of different ladar implementations.

PHASE III: The techniques developed could be applied to commercial Ladar systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed could be applied to commercial Ladar systems.

REFERENCES:
1. http://www.arete.com/index.php?view=optical_simulation
2. http://www.las-cad.com/
3. http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA133295

KEYWORDS: Sensors, LADAR, coherent detection, direct detection